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ABSTRACT

This final report contains an eight-page narrative and materials/products of a program to produce (the final) sixty-eight individualized machine shop skill tasks modules (and fifty-two master audio tapes for students with serious reading disabilities). The narrative also describes the determination of the vital few skills used by machine tool operators daily (out of 200 skills in the state curriculum guide) and validation of the learning strategy of ninety modules. These results are reported: (1) every skill task in the Machine Shop State Guide has individualized modules available for use in secondary and postsecondary schools; (2) the machine shop industry identified twenty-five psychomotor skills as used daily, thirty-three as used weekly, and eighty-nine as used monthly; (3) thirty-six modules were rated as valid; and (4) a new state guide for machine shop teachers containing 147 skills was developed. Appendixes include procedures followed to produce skill modules and audio tape masters, survey instrument, listings of the modules and master tapes produced, and survey data. The appended tentative articulated guide for machine shop contains performance objectives (in terms of classes of equipment) with a task description and performance criteria and student tracking forms. (YLB)

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Final Report

Project No. 498AH60276
Grant No. G007603817

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Weber State College
3750 Harrison Boulevard
Ogden, Utah 84408

DEVELOPMENT OF LEARNING MODULES FOR MACHINE SHOP OCCUPATIONS

December 1979

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U.S. DEPARTMENT OF HEALTH, EDUCATION AND WELFARE

Office of Education

National Center for Educational Research and Development

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
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ABSTRACT

This program was conducted to produce the final modules to complete individualization of skill training in machine shop; to determine the vital few skills used by machine tool operators on a daily basis; and to validate the learning strategy of the modules.

Sixty-eight modules were written and produced and were the final skills out of the 147 contained in the State Guide. Each module contains an industry time and accuracy standard. All skill tasks have now been individualized and are transportable.

A survey instrument containing all of the machine shop skills in the State Guide was developed and used to determine the vital few skills out of the many (Pareto's Law) that machine tool operators perform on a regular basis. If students learn to perform these few skills (about 20% of them) to the industry "time" and "accuracy" standards, they should be able to perform to the industry standard 70 to 80% of their time on the job.

Ninety modules were subjected to validation activity. Where 80% of the students could perform the skill task to within ± 15% of the student learning time contained on the module, the modules were determined valid as to strategy. Those modules not meeting the validation criteria are to have their content reworked and go through the validation process again.

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January 30, 1980

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U.S. DEPARTMENT OF
HEALTH, EDUCATION AND WELFARE

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PREFACE

The Utah State Department for Vocational Education, under the direction of Mr. Walter Ulrich, State Director, Dr. David Gailey, Specialist Post-Secondary Education, and Mr. Ralph Anderson, Specialist Secondary Education, have given leadership in the development of articulated secondary and post secondary vocational programs. They have encouraged the restructuring of courses and programs so they are performance based, individualized, open entry - open exit, and career ladder oriented. The Manufacturing Engineering Technology Department at Weber State College adopted these challenges as goals and set out to accomplish them.

The first effort undertaken by the Manufacturing Engineering Technology faculty was to develop 31 individualized psychomotor skill task modules in machine shop during the summer of 1974. The written modules were performance based, profusely illustrated and contained both industry time and quality standards as well as a student learning time standard. The leadership in the State Department for Vocational Education was impressed with the possibilities of the modules and encouraged us to seek additional resources to continue the work. An application for a U.S.O.E. grant was made and funded. During the months of June through September, 1976, 79 additional skill modules were written by 18 secondary and post-secondary machine shop instructors through U.S.O.E. Grant No. G007500324. The purpose of using a large number of instructors was to demonstrate that vocational instructors of secondary and post-secondary programs would use articulated curriculum materials when a sense of ownership of the materials was established. At this time we had 90 separate skill task modules with 20 duplicates of different equipment within a process such as lathes, vertical mills, drills, etc.

The Machine Shop State Guide contained approximately 215 skill tasks and so we were considerably short of having the total curriculum individualized. A second grant application was submitted to U.S.O.E. to develop an additional 70 to 75 machine shop skill modules and to validate those previously produced. The grant was funded and is the subject of this report.

The encouragement and support of the State Office for Vocational Education motivated us to action. We are deeply appreciative of their support. Special gratitude is expressed to Dr. Dale Cowgill, Dean, School of Technology, for his incisive and extremely valuable assistance given during the writing of the grant proposal and during the project performance period.

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INTRODUCTION

The Machine Shop Training Program in Utah has a state-developed curriculum guide. The state guide reflects extensive "task-analysis" effort in selecting appropriate skill tasks. Each skill task is written as a student performance objective. One thing the system lacked was a complete set of individualized learning modules for each of the machine shop skill tasks or objectives. This is especially important if open entry - open exit instruction is to be given so that a steady flow of trained students into the job market is possible. Funding of this grant allowed us to produce the final 68 skill modules for the machine shop curriculum. Also 52 master audio tapes were produced so that audio instructions could be given to students with serious reading disabilities.

Feedback from advisory committees and local industries uncovered a second suspected problem -- that of students leaving vocational programs unprepared to enter careers and perform at an industry level without significant time developing accuracy and speed in skill performance. This is because present programs train students to perform primarily at the "manipulation" skill level with a few skills being accomplished at the "precision" level of psycho-motor development while the industry standard is skill performance at the "articulation" level of psycho-motor development. Manipulation skill performance is demonstrated when the student can perform the complete skill task by following written instructions without any outside help. Performing the skill to a single quality standard, that of accuracy, is precision level performance in the machine shop. When a student can perform the skill task to two quality standards, those of accuracy and time, then articulation level performance has been accomplished and this is what industry desires. This means that skill tasks used in vocational courses must contain real industry based "accuracy" and "time" standards so that student performance at the articulation level of psychomotor skill development can be measured and certified. All machine shop skill modules developed by us contain these two standards of performance.

As the state guide contained more than 200 psychomotor skills, it would be impossible to train students to the articulation level in all of them in the normal time period of a machine shop training course. We, therefore, proposed to use Pareto's Law as a guide in finding the vital few skills among the many skills which should be taught. Pareto, an economist, found that there is a normal, natural maldistribution between causes and effects that can be described mathematically. Ordinarily, he noted, things distribute themselves in approximately a 20 to 80 ratio -- that is,

80 percent of the effects can be attributed to 20 percent of the possible causes. According to his law, for example, about 20 percent of the employees in a company will account for 80 percent of the absenteeism, or 20 percent of the inventory items will create 80 percent of the problems. Knowledge of this law or principle allowed us to prepare a survey to identify the vital 15 to 25 percent of the skills that are critical to job performance. Performance of these skills would take 70 to 80 percent of the employee's time on the job. Another 15 to 20 percent of the skills would, according to Pareto, take 15 to 20 percent of the employee's job time. The remaining 50 to 60 percent of the skills would be used only 10 to 15 percent of the job time. Identification of the vital few skills makes it possible to train machine shop students to the articulation level in these skills during the normal training time. Thus, the beginning employee would be fully productive 70 to 80 percent of the time on the job. These vital skills were identified as part of this research project.

Another task rising out of the grant was the development of a teacher's guide (management system) that describes how to use the instructional system effectively, allows instructors flexibility, and if used properly results in articulation between all participating machine shop programs in Utah. The guide was written as part of the project.

The final problem needing solution was that of validating the machine shop individualized skill task modules. The learning time standard contained in the module is a built-in validity check; if 80 percent of the students achieve this learning time standard within $\pm$ 15 percent, the unit is considered valid as to strategy. If a unit does not meet the validation criteria then modification must be made to the unit. Two secondary and two post-secondary shops were used in the validation process on the 80 available skill tasks.

PROCEDURE

Two replacement faculty were hired to free the regular faculty to write individualized machine shop skill modules, beginning in September, 1976, and continuing through May of 1977. Appendix 1 shows the detailed procedures used to produce the skill modules.

Accompanying the written module production activities were other activities to produce audio cassette tapes that could be used by students with reading disabilities. Our system required a tape that would verbally lead the student who could not read through the skill performance as illustrated in the written module. Audio masters were made following the procedures listed in Appendix 2.

To determine the vital few machine shop skills for which students should be trained to the articulation level, a survey form containing 157 machine shop skills listed in the state guide was developed. The guide contained over 200 skills tasks but some were eliminated from the survey document because they were clearly inspection or tool and die tasks and not basic machine shop skills. A group of fourteen Wasatch Front companies specializing in machine shop work or having machine shops as part of their operations were identified and visited by a member of our survey team. Sixty machine tool operators and their foremen supplied data for the survey. Specifically, they were asked to identify:

1. The skill tasks that were used daily (or at least three times per week) by machine tool operators in their shops.

2. The skill tasks used weekly (once or twice per week) by their machine tool operators, and

3. The skill tasks used monthly (fewer than two or three times per month) by their machine tool operators.

It was determined that those skills used essentially on a daily basis would be classified as articulation level psychomotor skills. If Pareto's Law is true in this situation, some 20 to 30 percent of the total number of skills would fit this category. A new employee who could perform these skills at the articulation level would be fully productive 70 to 80 percent of his/her time on the job.

If the skills were used essentially on a weekly basis, it would be less important for the beginning employee to be able to perform at the full industry standard (articulation

level). These less frequent tasks could be practiced on the job to acquire whatever speeds were necessary so long as the employee could work to sufficient accuracy. Application of Pareto's Law predicts that 15 to 20 percent of the machine shop skills should fit this classification. The skills so identified would be used to train students to the precision level since accuracy is necessary but concurrent speed is significantly less important.

Skills used only a few times a month would be classified for attainment of manipulation level skill only. Certainly the new employee should have "done it" properly at least once before encountering it on the job, but if the skills which occupy 80 to 90 percent of the job have been adequately developed, both the employee and employer can afford some carefully guided practice on these seldom encountered skills. We anticipated that 50 to 60 percent of the listed skills would fall into this category, and would occupy less than 10 percent of job time.

Data was collected and tabulated. A letter mailed to each participating company, the survey instrument with instruction sheet, and a list of the companies surveyed are included as Appendix 3.

A tentative teachers guide was written and delivered in late August, 1976, with copies of 80 different machine shop skill modules, to machine shop instructors at Kearns High School, Viewmont High School, Utah Technical College at Salt Lake and Weber State College. Additional modules were delivered throughout the year as they were completed. The modules were used in each of the machine shop programs during the 1976/77 school year. Each student was asked to fill out an evaluation form (Appendix 4) for each skill task performed. The forms were collected and the data tabulated including the time taken to perform the skill task. The student's actual time to complete the module was very important in the module validation process. The module strategy is rated as valid if 80 percent of the students perform within ± 15 percent of the learning time standard contained in the module. If less than 80 percent achieve the standard, modification must be made to the unit.

It should be pointed out that only 80 completed modules were ready for use and validation in August, 1976. Ten additional modules were in the final stages of production as a result of the summer activities on a previous grant, and were delivered to participating shops in October. During the 1976/77 school year 68 more modules were written, produced and delivered.

To make certain that the modules contain no sex biased content they were presented to the Weber State College Women's Commission for review and certification. (See Appendix 5)

RESULTS AND FINDINGS

1. Sixty-eight individualized machine shop skill task modules were written and produced. (See Appendix 6)

2. Every skill task contained in the Machine Shop State Guide has individualized modules available for use in secondary and post-secondary schools. (See list in state guide attached as Appendix 10)

3. Forty-five audio cassette master tapes were produced and seven additional tapes were developed to final edit stage. (List contained in Appendix 7)

4. Table 1 summarizing the findings of the survey that identified the machine shop skills for which students should be trained to perform at the articulation, precision and manipulation psychomotor skill levels is shown below. Preto's Law was the basis for the predicted results.

Table 1

Summary of Machine Shop Skills
at the Various Psychomotor Skill Levels

Psychomotor Skill Level	Number of Skills	Percent of Total Skills	Predicted Percent (Pareto)
Articulation	25	17	20
Precision	33	23	20
Manipulation	89	60	60
TOTAL	147	100	100

It is obvious that the findings are very close to Pareto's predictions. Twenty-five skills, the vital few, were identified as being used on a daily basis by machine tool operators in shops on the Wasatch Front. This is 17 percent of the total skills contained in the survey document. Students should learn to perform these at the articulation level where they must meet both industry standards for accuracy and time. This will prepare them to be fully productive 70 to 80 percent of the job time.

Another 33 skill tasks were identified as being used one to three times per week and were classified to be taught to the precision level of psychomotor skill development. This requires student performance to the industry accuracy standard. Twenty-three percent of the skills fell into this category.

Sixty percent, or 89 skills, were classified at manipulation level because they were only used a few times each month. Students should perform these skill tasks one time only so they know that they exist.

Ten skills included on the survey instrument were dropped from the state guide because they were not performed at all by the machine tool operators. This reduced the number of skills from 157 to 147 to be included in the state guide.

The list of the individual machine shop skills with the appropriate skill level designation is shown in Appendix 8.

5. Table 2 shows the findings of the validating effort.

Table 2

Summary of Validation Findings for Machine Shop Skills

Valid	Not Valid	Sample Too Small	Total
36	14	25	75

If 80 percent of the students performing the skill completed it in less than the student learning time (+ 15%) then the module was considered valid as to strategy. Thirty-six modules were rated as valid based on this criteria and fourteen not valid. With 25 modules, the sample of students performing the skill task was too small to determine validity. Appendix 9 contains the detailed information on validation of the learning module.

6. A significant result was the development of a new state guide for machine shop teachers. The system was accepted by the state vocational director and staff to the point that the author and three other machine shop instructors were commissioned to organize the materials into a new articulated state guide. The original teachers guide used on this research project was modified slightly and submitted for acceptance as the state articulated guide for machine shop. (See Appendix 10)

Other Findings

The instructors involved in the study reported that many students did not like the reading entailed in using the written modules. Our system required a live demonstration by the instructor (imitation psychomotor skill level) and then the student was expected to perform at the manipulation psychomotor skill level. Manipulation level skill attainment involves performance of the skill according to the specific set of instructions given in the written module. This is a significant departure from that normally encountered in the machine shop training where the instructor gives a live demonstration and the student is expected to perform the skill task from memory. Some students objected to the reading requirement.

Another finding was that because of the individual differences in learning rate, student performance was soon scattered over a wide range of machine shop skills. For instruction to be most effective, the machine shop instructors were required to give repeated live demonstratons. This proved onerous and demotivating to them.

CONCLUSIONS

The data and informal observations of the staff support these conclusions:

1. The entire machine shop curriculum of skill tasks (147 skills) has been individualized and is transportable to any machine shop training program. All modules contain industry time and accuracy standards.

2. Fifty-two of the most used skill tasks have audio tape masters from which copies can be made and used by students with reading disabilities. These tapes describe the performance activity the student must do in support of the highly illustrated, written modules.

3. A survey of the machine shop industry, using Pareto's Law as a guide, helped us to identify the few skills out of the many that are used on a daily basis by machine tool operators. Students can be trained to perform at the industry time and accuracy standards on these skills and will be fully productive 70 to 80% of their time on the job as an operator. This survey technique may be used in any locality or with any single company to determine the vital few skills for which performance at the industry standard can be accomplished in local training programs.

4. The validation process was successful in identifying skill task modules that are valid as to strategy. It also identified those modules whose strategy needed to be changed in order to be valid.

5. A State Guide For Machine Shop Training was produced and delivered to all programs in Utah. If used correctly, the result can be complete articulation of all programs in the state.

RECOMMENDATIONS

1. There is a need to make audio tape masters for the remaining 95 machine shop skills for use by students with reading disabilities.

2. The validation process needs to be completed for all 147 skill task modules. Those not meeting the validation criteria should be altered and subjected to a second validation process.

3. Because of individual differences, students are soon spread over a large area of performance in any skill training program. This requires repeated live demonstrations by faculty and becomes tiresome and boring. Under those conditions, instruction may not be given at appropriate times that are effective in the individual student's learning cycle, or the instruction may be of poor quality. Thus, there is a need to produce moving picture films or T.V. tapes of all demonstrations of the machine shop skills if individualized, open entry-exit programs are to be realized.

Appendix 1

Procedures Followed to Produce Skill Modules

The following procedures have been efficient and effective in producing the skill modules.

The faculty member takes an assigned skill objective from the state guide and:

1. Peruses the pertinent literature and writes the step-by-step learning procedures necessary to accomplish the objective. All equipment, tools and materials are identified and the prerequisite knowledge and skills are listed. This is written to a standard format.

2. Carries the written material to a typist and has a first draft typed.

3. Determines the technical illustrations needed to supplement the written material. He then goes into the shop, and using a polaroid camera for immediate feedback, photographs actual set-ups of equipment, tools and people.

4. Takes the photographs to a technical illustrator who draws the necessary illustrations from the photographs. The illustrations are made oversize so that picture content is clear and definite.

5. Reduces the technical illustrations to a standard size on a copy machine that has reduction capacity.

6. Pastes or tapes the standard size illustrations to the typed manuscript.

7. Has a neutral party edit the modules for format, content, clarity and completeness.

8. Has any modifications made to the illustrations or adds illustrations if needed. The manuscript is retyped, and the standard size illustrations are taped into position.

9. Determines the time standards for the unit and has them typed onto the module.

10. The module is given a final edit and review and is now ready for photocopy reproduction process.

Appendix 2

Procedures Followed to Produce Audio Tape Masters

1. The script writer was assigned a machine shop skill task. Using the written module as reference, an audio script was written.

2. The written material was typed to a standard format.

3. A cassette tape recording was made of the written script. One male and one famale reader were used in this process.

4. The recording was reviewed by a machine shop expert and necessary changes identified.

5. The pertinent reader recorded the changes and the changes were edited into the cassette tape.

6. The recording was reviewed a second time by the machine shop expert.

7. If no changes were needed, a master tape was produced. If additional changes were necessary, the changes were recorded, reviewed and then a master produced.

SCHOOL OF TECHNOLOGY–
MANUFACTURING ENGINEERING
TECHNOLOGY

OGDEN, UTAH 84408
801-626-6305

WEBER STATE COLLEGE

Appendix 3a

Dear _____:

The Manufacturing Engineering Technology Department is engaged in a project to improve the quality of instruction and the efficiency of learning by developing self-learning skill modules in the machine shop, welding and engineering graphics areas. We need your help in determining which skills are used by the various levels of skilled employees in your organization. We also realize the skills list is not complete and welcome any additions you feel are necessary.

We are using Pareto's Law as a guide in determining: (a) the vital 20 - 30% of the skills that an operator uses 70 - 80% of the time, (b) the 20% of the skills he uses 20% of the time, and (c) the 50% of the skills used 10% of the time.

With this information we would know which skills to concentrate our efforts on. Specifically, we feel the student should perform the vital 20 - 30% of the skills at the "articulation" level; that is, they should meet industry standards for time and quality (accuracy). The next 20% of the skills the student should perform at the "precision" level; that is, meet the industry standard for quality, with time as only a secondary factor. The last 50% of the skills the student should perform at the "manipulation" level; that is, demonstrate that he can properly follow instructions to perform the work.

We feel our approach is unique in the field and will improve and make more efficient the teaching of skills. It will also insure that an employee will be productive for you at his entrance into the job market. Will you please take some time from your busy schedule to go through this survey with us and rate the skills as objectively and honestly as you can. We realize the list is long, and we will be happy to go through it with you or if you prefer, we will leave the survey with you to do at your leisure. Either way, we honestly appreciate your efforts.

Thank you,

Robert E. Wallentine, Associate Professor
Manufacturing Eng. Tech. Phone: 399-5941, Ext. 715

cr

Enclosure

Company: _____

INSTRUCTIONS:

1. Please list your job title or function in the organization and your years of experience in machine shop-related work.

   Job title _____ years of experience _____

2. Read the four job descriptions and list, in the proper blank, a job title from your organization that most closely matches those described.

   JOB DESCRIPTION:

   Specific Machine Tool Operator: A person who operates only one specific machine or class of machines including tape controlled. He does not set up the machine but does position the work on the machine, operate the controls and verify dimensions using specific gages. Dictionary of Occupational Titles (DOT) #603-280, 606-782, 609-782, 615-782, 615-885. Your organization's job title that best fits this job description: _____.

   Specific Machine Tool Set-Up Operator: A person who sets up and operates a specific machine or class of machines. He reads blueprints, makes some calculations, verifies location of tooling using micrometers, calipers, etc., verifies part dimensions. DOT #603-280, 604-280, 604-380, 605-380, 603-782, 606-280, 606-380, 606-782, 609-380. Your organization's job title that best fits this job description: _____.

   General Machine Set-Up & Operator: Same as the above but for all general purpose machine tools. DOT #600-380, 601-280, 603-280, 616-380, 619-885. Your organization's job title that best fits this job description: _____.

   Tool & Die Trainee: Analyze specifications, lays out work, sets up and operates various machine tools. Assembles, fits and repairs dies, cutting tools, jigs, fixtures and gages. Verifies dimensions using standard measuring tools and gages. Tool programmer plans program for machining parts, calculates feeds and speeds, selects cutting tools, writes programs for key punch operators, verifies tapes, and checks 1st piece. DOT #600-280, 601-280, 601-281, 649-885, 007-187. Your organization's job title that best fits this job description: _____.

3. Go through the list carefully and indicate the frequency that each job title uses each skill. If you feel the skill is never used by an employee in a particular job title, do not put a number in any of the boxes.

4. We realize the skill list may not be complete, so space is available at the end of each section for you to add and rate additional skills.

5. An example is listed and a sample rating given.

[illegible]LL TASK	JOB DESCRIPTION											
	Gen. Mach. Set-Up & Oper.			Tool & Die Trainee			Spec. Mach. Tool Set-Up & Oper.			Spec. Mach. Tool Oper.		
Lathe I	freq. of skill use			freq. of skill use			freq. of skill use			freq. of skill use		
	da	wk	mo	da	wk	mo	da	wk	mo	da	wk	mo
Shoveling snow												
1. Grinding a right hand turning tool												
2. Lathe operating control familiarity												
3. Install & remove chucks & face plates-cam lock spindle type												
4. Install & remove chucks & face plates-threaded nose spindle type												
5. Install & remove chucks & face plates-taper key drive nose spindle type												
6. Rough centering in a 4-jaw chuck												
7. Facing in a chuck												
8. Center drilling in chucks & collets												
9. Alignment of lathe centers												
10. Mounting work pieces between centers												
11. Straight turning between centers												
12. Knurling												
13. Taper cutting--offset method												
14. Straight turning work held in a chuck on an engine lathe												
15. Precision centering work for turning in a 4-jaw independent lathe												
16. Cutting steep tapers & chamfers												
17. Drilling in a lathe												
18. Reaming in a lathe												
19. Grooving & parting, operations in an engine lathe												
20. Grinding a 60 degree threading tool												
21. Cutting external unified standard screw threads												
22. Grinding a radius tool												
23. Grinding a round nose form tool												
24. Radius & fillet turning												
25. Boring in an engine lathe												

SKILL TASK

JOB DESCRIPTION

Lathe I (continued)

	Gen. Mach. Set-Up & Oper.			Tool & Die Trainee			Spec. Mach. Tool Set-Up & Oper.			Spec. Mach. Tool Oper.		
	freq. of skill use			freq. of skill use			freq. of skill use			freq. of skill use		
	da	wk	mo	da	wk	mo	da	wk	mo	da	wk	mo
26. Cutting internal unified standard screw threads												
27. Center drilling work between centers												
28. Grinding a right hand facing tool												
29. Facing work to length between centers												
30. Taper turning in an engine lathe--taper attachment method												
31. Tapping threads in a lathe												
32. Mounting, facing & turning work on a mandrel												
33. Cutting multiple entry threads-internal												
34. Cutting multiple entry threads-external												
35. Cutting on ACME thread												
36. Boring an internal taper												
37. Reaming a tapered hole												
38. Using a follower rest												
39. Using a steady rest												

Measurement I

1. Measuring with a steel rule												
2. Measuring with an outside micrometer												
3. Measuring with a vernier caliper												
4. Measuring with an inside micrometer												
5. Measuring with small hole gages (ball)												
6. Measuring with telescope gages												
7. Measure squareness with a precision square & combination square												
8. Measure with a depth micrometer												
9. Measure with a depth rule												
10. Measure with adjustable parallels												

SKILL TASK

Measurement I (continued)

	JOB DESCRIPTION											
	Gen. Mach. Set-Up & Oper.			Tool & Die Trainee			Spec. Mach. Tool Set-Up & Oper.			Spec. Mach. Tool Oper.		
	freq. of skill use			freq. of skill use			freq. of skill use			freq. of skill use		
	da	wk	mo	da	wk	mo	da	wk	mo	da	wk	mo
11. Measure with a vernier protractor												
12. Measure angles & taper with a sine plate												
13. Measure angles & taper with a rotab												
14. Measure hole diameters with deltronic pins												
15. Measure with dial bore gages												
16. Measure with intra-micrometers												
17. Measure with radius gages												
18. Measure with the optical comparitor												
19. Measure with thread micrometers												
20. Measure thread pitch diameters (3 wire method)												
21. Measure thread pitch diameters (GO; NO-GO Method)												
22.												
23. Measure thread pitch diameters (Thread triangle method)												
24. Check concentricity (Center & indicator method)												
25. Check concentricity (V-block & indicator method)												
26. Check concentricity (comparator method)												
27. Measure with a mono light & optical flats												
28. Measure with the federal high amplification gage												
29. Measure with an air gage												
30. Measure with a plug gage												
31. Measure with a vernier gear tooth gage												
32. Measure hardness of metal with a Rockwell hardness tester												
33. Measure surface roughness with a talysurf												

SKILL TASK

Measurement I (continued)

	JOB DESCRIPTION											
	Gen. Mach. Set-Up & Oper.			Tool & Die Trainee			Spec. Mach. Tool Set-Up & Oper.			Spec. Mach. Tool Oper.		
	freq. of skill use			freq. of skill use			freq. of skill use			freq. of skill use		
	da	wk	mo	da	wk	mo	da	wk	mo	da	wk	mo
34. Measure surface roughness with a profilometer												
35. Measure with the tool makers microscope												
36. Measure with the super micrometer												
37. Check surface imperfections with the magnaflux												
38. Check hole locations by coordinate method (surface plate set up)												
39. Check true position of hole location												
40. Make dye penetrant inspection												
41. Measure with the Webber optical transfer height gage												
42. Measure squareness with the cylindrical square												
43. Read a protractor												

Milling Machine I (Vertical)

	da	wk	mo	da	wk	mo	da	wk	mo	da	wk	mo
1. Vertical milling machine operating control familiarity												
2. Square a piece of work clamped to the mill table												
3. Layout a workpiece for drilling												
4. Locating drilling & reaming holes by the coordinate method												
5. Locating & boring holes by the coordinate method												
6. Chuck an end mill in a collet in the spindle												

SKILL TASK

JOB DESCRIPTION

Milling Machine I (continued)

	Gen. Mach. Set-Up & Oper.			Tool & Die Trainee			Spec. Mach. Tool Set-Up & Oper.			Spec. Mach. Tool Oper.		
	freq. of skill use			freq. of skill use			freq. of skill use			freq. of skill use		
	da	wk	mo	da	wk	mo	da	wk	mo	da	wk	mo
7. Step drilling holes accurately to size												
8. Mount & align a vise to the mill table												
9. Align spindle perpendicular to table (sweep the table)												
10. Square a piece of work held in a vise												
11. Locate & mill a slot and/or pocket												
12. Countersinking, counterboring, & spotfacing												
13. Mill a hexigon or a square on a workpiece												
14. Mill a "T" slot												
15. Drill holes using a drill jig												
16. Machine a circular slot with rotary table												
17. Mill a part using a 180 degree tracer unit												
18. Machine a taper or wedge using the tilting table												
19. Machine a fillet corner with a ball mill												
20. Machine a flat surface using a fly-cutter												
21. Machine a dovetail												
22. Drill & bore evenly spaced holes on a bolt circle												
23. Mill multi-level surfaces accurately												

Horizontal Milling Machine

1. Machine operation control familiarity												
2. Install an arbor in the spindle socket												
3. Install a cutter on the milling machine arbor												

SKILL TASK

JOB DESCRIPTION

Horizontal Milling Machine (continued)

	Gen. Mach. Set-Up & Oper.			Tool & Die Trainee			Spec. Mach. Tool Set-Up & Oper.			Spec. Mach. Tool Oper.		
	freq. of skill use			freq. of skill use			freq. of skill use			freq. of skill use		
	da	wk	mo	da	wk	mo	da	wk	mo	da	wk	mo
4. Square a piece held in a vise using a slabmill												
5. Face mill a part clamped to the table												
6. Straddle mill a part clamped to the table												
7. Cut a keyway in a shaft with a plain milling cutter												
8. Cut the teeth on a spur gear-with the aid of a dividing head												
9. Machine a cross slot in a shaft												
10. Machine a woodruf key seat												
11. Machine an external radius												
12. Mill an angular slot												
13. Machine a hexigon by straddle milling												
14. Machine slots on work held in a fixture												
15. Slit work held in a vise												
16. Do gang milling												
17. Machine a compound angle with the universal vise												
18. Do helical milling												
19. Mill work clamped to an angle plate												
20. Drilling & ream work												
21. Line bore 3 or more holes												

Do-All Saw I

1. Sawing machine operation control familiarity												
2. Setting up a set of saw guides												
3. Set up the saw for sawing												

SKILL TASK

Do-All Saw I (continued)

JOB DESCRIPTION											
Gen. Mach. Set-Up & Oper.			Tool & Die Trainee			Spec. Mach. Tool Set-Up & Oper.			Spec. Mach. Tool Oper.		
freq. of skill use			freq. of skill use			freq. of skill use			freq. of skill use		
da	wk	mo	da	wk	mo	da	wk	mo	da	wk	mo

4. Set up the do-all saw for filing
5. Butt weld a blade
6. Stack sawing
7. Internal sawing

Power Hack Saw I

1. Power hack saw operation control familiarity
2. Install a hacksaw blade
3. Cut off stock in the power hacksaw

Grinding Machines I

1. Blanchard grinder operation control familiarity
2. Dress the blanchard grinding wheel
3. Blanchard grind a part parallel & to size
4. Cylindrical grinder operation control familiarity
5. Dress the grinding wheel

6. Grind a cylindrical part between center points
7.
8.
9.

SKILL TASK

JOB DESCRIPTION

Grinding Machines I (continued)

	Gen. Mach. Set-Up & Oper.			Tool & Die Trainee			Spec. Mach. Tool Set-Up & Ope .			Spec. Mach. Tool Oper.		
	freq. of skill use			freq. of skill use			freq. of skill use			freq. of skill use		
	da	wk	mo	da	wk	mo	da	wk	mo	da	wk	mo
10. Surface grinder operation control familiarity												
11. Dress the surface grinding wheel												
12. Grind a part parallel & to size												
13.												
14.												
15.												
16. Bench or floor type grinder operation control familiarity												
17. Dressing a grinding wheel												
18. Centerless grinder operation control familiarity												
19. Grinding rods in a centerless grinder												

Layout & Bench Work I

1. Rough layout of a part												
2. Precision layout of a part												
3. Cutting stock with a hand hacksaw												
4. Straight & draw filing												
5. Sizing holes with hand reamers												
6. Cutting threads by hand with tap & die												
7. Deburring												
8. Removing broken studs												

Appendix 3c

Companies Surveyed to Determine Skill Level (Manipulation, Precision, Articulation) of Machine Shop Skills.

	Company	Address	No. of Employees Interviewed
1.	Dynapac Inc.	1630 S. Industrial Road Salt Lake City, Utah	2
2.	E-Systems Inc.	2268 S. 3270 W. Salt Lake City, Utah	3
3.	Eimco Process Machinery Division Envirotech Corp.	669 W. 200 S. Salt Lake City, Utah	4
4.	Flameco Engrg. Inc.	2620 Pennsylvania Ave. Ogden, Utah	6
5.	Galigher Co.	440 West 800 South Salt Lake City, Utah	4
6.	General Electric Co. Termi-Net Service	130 E. 1100 N. North Salt Lake City, Utah	3
7.	Hill Air Force Base Maintenance Directorate	Ogden, Utah	8
8.	Kenway Inc.	525 W. 350 N. Bountiful, Utah	3
9.	Price-Robinson Machine Shop	1578 W. 1700 S. Syracuse, Utah	1
10.	Process Systems Inc.	356 W. 700 S. Salt Lake City, Utah	5
11.	Thiokol - Logan Div.	2503 North Main Logan, Utah	8
12.	Thiokol - Wasatch Division	Brigham City, Utah	8
13.	Utah Tool & Die Inc.	1770 West 500 South Salt Lake City, Utah	2
14.	Williams Research Corporation	3450 Sam Williams Drive Ogden, Utah	3

Appendix 4

Machine Shop Evaluation Form

Directions: In order to effectively evaluate this course we need your input. Please be as honest as possible while completing the following anonymous form. All of the questions will be evaluated and changes will be made in the course from what is said on the evaluation forms. Once you have completed the form please turn it in at the appropriate location.

Skill Task #_____ Skill Task Name_____

1. Were you able to complete the Skill Task without help? Yes___ No___

2. How many times did you attempt the Skill Task before you were able to complete it by yourself? No._____

3. Did you see a demonstration or film of this Skill Task before doing it on your own? Yes___ No___

4. Did the demonstration clarify the procedure to be followed in the Skill Task? Yes___ No___

5. Did the demonstration increase your interest in doing this Skill Task? Yes___ No___

6. Were the objectives for the Skill Task clear to you? Yes___ No___

7. Did the module help you accomplish the objectives? Yes___ No___

8. At which steps in this Skill Task did you need other help than that provided by the learning unit itself? Step #_____ Step #_____ Step #_____

9. List the worst thing about this Skill Task.

10. List the best thing about this Skill Task.

11. Time to perform this machine shop Skill Task_____.

Appendix 5

The Weber State College Women's Commission has reviewed the 147 written Machine Shop Individualized Skill Modules and found them free of sex bias content.

Lucie M. Swanson

Lucie M. Swanson, Chairperson
Weber State College Women's Commission

Appendix 6

Machine Shop Individualized Skill Learning Tasks Produced

DO-ALL SAW I

1. Sawing to layout lines

DRILLING MACHINE I

2. Mount and hold work on the drill press.
3. Drill holes to layout lines.
4. Drill holes through the center of round stock.
5. Step drill holes accurately to size.
6. Drill holes using a drill jig.
7. Countersink, counterbore and spotface.
8. Ream holes to size.
9. Tap holes in drill press by hand.

ELECTRICAL DISCHARGE MACHINE I

10. Machine a hardened workpiece

GRINDING MACHINES I

11. Surface grinder operation control familiarity.
12. Dress surface grinding wheel.
13. Grind a part parallel to the size.
14. Remove and mount a surface grinding wheel.
15. Remove and mount a grinding wheel on tool and cutter grinder.
16. Grind a tapered part between center points.
17. Tool and cutter grinder operation control familiarity.
18. Grinding a cutting tool to print or signature.

HEAT TREATMENT I

19. Electric furnace control familiarity.
20. Gas furnace control familiarity.

HONE MACHINE I

21. Size and finish a hole.

HORIZONTAL MILLING MACHINE I

22. Cut keyway in shaft with plain milling cutter.
23. Machine an external radius.
24. Mill an angular slot.
25. Mill multi-level surfaces.

JIG BORER I

26. Operational control familiarity.
27. Locating, drilling and reaming holes - coordinate method.
28. Locating and boring holes by coordinate method.

LATHES I

29. Lathe control familiarity (LeBlond Regal).
30. Rough and finish turning using cemented carbides and ceramics.
31. Changing jaws in a 4-jaw independent chuck.
32. Changing the jaws in a 3-jaw universal chuck with a set of inside and outside jaws.
33. Reversing the jaws in a 3-jaw universal chuck with cap screw mounted jaws.
34. Matching a part with a tracing attachment.

LAYOUT AND BENCHWORK I

35. Lapping a surface on a lap plate.
36. Filing contours with a reciprocating filing machine.
37. Breaching keyway on arbor press.
38. Center drilling in center drilling machine.

MEASUREMENT I

39. Measuring with a dial indicator.
40. Measuring angles and taper with a sine plate.
41. Measure with dial bore gages.
42. Measure with intra-micrometers.
43. Measure with radius gages.
44. Measure with optical comparator.
45. Measure with thread micrometers.
46. Measure thread pitch dia. (GO, No-Go).
47. Check concentricity (center and indicator).
48. Measuring with a thread plug gage.
49. Measure hardness of metal with a Rockwell Hardness Tester.
50. Measuring with the toolmakers microscope.
51. Check hole location by coordinate method (surface plate set-up).
52. Check hole location by true position method.
53. Check precision square for squareness with cylindrical square.
54. Check squareness with a precision square.
55. Checking surface finish with a surface comparator gage.
56. Measure hole dia. with deltronic pins.

NUMERICAL CONTROL I

57. Operational control familiarity (P & W)
58. Operational control familiarity (Bostomatic).

VERTICAL MILLING MACHINE I

59. Square a piece of work clamped to the mill table.
60. Mill a square on a workpiece.
61. Mill a hexagon on a workpiece.
62. Machine flat surface using fly cutter.
63. Drill and ream equally spaced holes on a bolt circle using direct indexing.
64. Drill and ream equally spaced holes on a bolt circle using simple indexing.
65. Mill a part using tracer unit.
66. Machine a taper or wedge using a tilting table.
67. Tap holes on the vertical mill using a tapping attachment.
68. Drill holes using a drill jig.

Appendix 7

Cassette Tapes for Machine Shop Individualized Learning Tasks

MASTER TAPES PRODUCED

DO-ALL SAW I

1. Contour saw operation control familiarity.
2. Mount up a set of saw guides.

DRILLING MACHINE I

3. Drill press operational control familiarity.
4. Tap holes in drill press by hand.

GRINDING MACHINES I

5. Bench or floor type grinder operation control familiarity.
6. Dressing a floor type grinding wheel.
7. Blanchard grinder operational control familiarity.
8. Dress a blanchard grinding wheel.
9. Dress surface grinding wheel.

HORIZONTAL MILLING MACHINE I

10. Install arbor in the spindle.
11. Install a cutter on the arbor.
12. Slab mill a piece square held.

LATHES I

13. Grinding a right hand turning tool.
14. Lathe operator control familiarity. (P & W)
15. Lathe control familiarity (LeBlond Regal)
16. Install and remove chucks and face plates - taper key.
17. Straight turning between centers.
18. Knurling.
19. Precision centering in a 4-jaw chuck.
20. Cutting steep tapers and chamfers.
21. Reaming in a lathe.
22. Grind a 60° threading tool.
23. Cutting external threads.
24. Grinding a radius tool.
25. Grinding a round nose form tool.
26. Radius and fillet turning.
27. Boring in an engine lathe.
28. Cutting internal threads.
29. Facing work to length between centers.
30. Tapping threads in a lathe.

LAYOUT AND BENCH WORK I

31. Hand methods of deburring parts.

MEASUREMENT I

32. Measure with inside mike.
33. Measure with small hole gages.
34. Measure with depth mike.
35. Measure with dial bore gages.
36. Measure with optical comparator.
37. Measure thread pitch dia. (GO, No-Go).
38. Check concentricity (center and indicator).

POWER HACK SAW I

39. Power hack saw operational control familiarity.
40. Install hack saw blade.
41. Cut off stock in the power hack saw.

VERTICAL MILLING MACHINE I

42. Square work held in a vise.
43. Locate, drill and ream holes coordinate method.
44. Mill multi-level surfaces.
45. Machine flat surface using fly cutter.

TAPES RECORDED - NOT EDITED

DO-ALL SAW I

46. Mount and remove a saw band.

LATHE I

47. Alignment of lathe centers
48. Mount work between centers.
49. Drilling in a lathe.

MEASUREMENT I

50. Measure with radius gage.
51. Check squareness with a precision square.

VERTICAL MILLING MACHINE I

52. Drill and ream equally spaced holes on a bolt circle -- simple indexing.

Appendix 8

PSYCHOMOTOR SKILL LIST - MACHINE TOOL OPERATOR, GENERAL

SKILL LEVEL: Articulation = A Precision = P Manipulation = M

		Skill Level
DO-ALL SAW I		
1.	Contour saw operation control familiarity	P
2.	Butt weld a blade.	M
3.	Mount up a set of saw guides.	M
4.	Mount and remove a saw band.	P
5.	Mount and remove a file band.	M
6.	Sawing to layout lines.	M
DRILLING MACHINE I		
1.	Drill press operation control familiarity.	A
2.	Sharpen a drill by hand.	P
3.	Mount and hold work on the drill press.	P
4.	Drill holes to layout lines.	M
5.	Drill holes through the center of round stock.	M
6.	Step drill holes accurately to size.	P
7.	Drill holes using a drill jig.	M
8.	Countersink, counterbore and spotface.	P
9.	Ream holes to size.	P
11.	Tap holes in drill press by hand.	P
GRINDING MACHINES I		
1.	Bench or floor type grinder operation control familiarity.	A
3.	Dressing a floor type grinding wheel.	P
4.	Blanchard grinder operational control familiarity.	M
5.	Dress a blanchard grinding wheel.	M
6.	Blanchard grind part parallel and to size.	M
7.	Surface grinder operation control familiarity.	M
8.	Dress surface grinding wheel.	P
9.	Grind a part parallel and to size.	P
10a.	Remove and mount a surface grinding wheel.	M
10b.	Remove and mount a grinding wheel on tool and cutter grinder.	M
12.	Cylindrical grinder operational control familiarity.	M
13.	Dress cylindrical grinding wheel	M
14.	Grind a cylindrical part between centers.	M
15.	Grind a tapered part between center points.	M
16.	Tool and cutter grinder operation control familiarity.	M
17.	Grinding a cutting tool to print or signature.	M
HORIZONTAL MILLING MACHINE I		
1.	Operation control familiarity.	M
2.	Install arbor in the spindle.	M
3.	Install a cutter on the arbor.	M
4.	Slab mill a piece square held in a vise.	M
5.	Face mill a part clamped to table.	M

HORIZONTAL MILLING MACHINE I (Cont.)

		Skill Level
6.	Straddle mill a part clamped to table.	M
7.	Mount dividing head and foot stock.	M
8.	Cut teeth on a spur gear.	M
9.	Cut keyway in shaft with plain milling cutter.	M
13.	Machine an external radius.	M
14.	Mill an angular slot.	M
17.	Slit work held in vise.	M
23.	Mill multi-level surfaces.	M

LATHES I

1.	Grinding a right hand turning tool.	A
2.	Lathe operator control familiarity.	A
3.	Install and remove chucks and face plates - cam lock.	M
4.	Install and remove chucks and face plates - thr'd nose.	M
5.	Install and remove chucks and face plates - taper key.	M
6.	Rough centering in a 4-jaw chuck.	P
7.	Facing in a chuck.	A
8.	Center drilling in chucks and collets.	A
9.	Alignment of lathe centers.	M
10.	Mounting work between centers.	M
11.	Straight turning between centers.	M
12.	Knurling.	M
13.	Taper cutting - offset method.	M
14.	Straight turning work in a chuck.	A
15.	Precision centering in a 4-jaw chuck.	M
16.	Cutting steep tapers and chamfers.	A
17.	Drilling in a lathe.	A
18.	Reaming in a lathe.	A
19.	Grooving and parting operations.	P
20.	Grind a 60° threading tool.	M
21.	Cutting external threads.	M
22.	Grinding a radius tool.	M
23.	Grinding a round nose form tool.	M
24.	Radius and fillet turning.	P
25.	Boring in an engine lathe.	A
26.	Cutting internal threads.	M
27.	Center drilling work between centers.	M
28.	Grinding a right hand facing tool.	M
29.	Facing work to length between centers.	M
30.	Taper turning - taper attachment.	M
31.	Tapping threads in a lathe.	P
32.	Mounting, facing and turning work on a mandrel.	M
33.	Rough and finish turning using cemented carbides and ceramics.	P
35a.	Changing jaws in a 4-jaw independent chuck.	M
35b.	Changing the jaws in a 3-jaw universal chuck with a set of inside and outside jaws.	M
36.	Machining a part with a tracing attachment.	M
37.	Reaming a tapered hole.	M
38.	Using a steady rest.	

		Skill Level
LAYOUT AND BENCHWORK I		
1.	Rough layout.	P
2.	Precision layout.	P
3.	Sawing with hand hack saw.	M
4.	Straight and draw filing.	M
5.	Sizing holes with hand reamers.	M
6.	Cutting threads by hand with taps.	M
7.	Hand methods of deburring parts.	A
8.	Hand methods of removing broken stubs.	M
9.	Cutting threads by hand with dies.	M
15.	Center drilling in center drilling machine.	M
MEASUREMENT I		
1.	Measure with steel rule.	A
2.	Measure with outside micrometer.	A
3.	Measure with vernier caliper.	A
4.	Measure with inside mike.	A
5.	Measure with small hole gages.	A
6.	Measure with a telescoping gage.	P
7.	Measure with a depth rule.	M
8.	Measure with depth mike.	A
9.	Measure with depth vernier.	M
10.	Measuring with protractors.	P
11.	Measuring with a dial indicator.	A
12.	Measuring angles and taper with a sine plate.	M
13.	Measure with dial bore gages.	A
14.	Measure with intra-micrometers.	P
15.	Measure with radius gages.	A
16.	Measure with optical comparator.	M
17.	Measuring with thread micrometers.	M
18.	Measure thread pitch dia. (GO, No-Go).	A
19.	Check concentricity (center and indicator).	P
21.	Measuring with a thread plug gage.	P
22.	Measure hardness of metal with a Rockwell Hardness tester.	M
23.	Measuring with the toolmakers microscope.	M
24.	Check hole location by coordinate method (surface plate set-up).	M
25.	Check hole location by true position method.	M
26.	Check precision square for squareness with cylindrical square.	M
27.	Check squareness with a precision square.	P
28.	Checking surface finish with a surface comparator gage.	M
29.	Measure hole dia. with deltronic pins.	M
POWER HACK SAW I		
1.	Power hack saw operational control familiarity.	M
2.	Install hack saw blade.	M
3.	Cut off stock in the power hack saw.	P

VERTICAL MILLING MACHINE I	Skill Level
1. Vertical milling operational control familiarity.	M
2. Chuck end mill in collet in spindle.	M
3. Align spindle perpendicular to table.	P
4. Mount and align a vise to the table.	A
5. Square a piece of work clamped to the table.	P
6. Square work held in a vise.	A
7. Locate, drill and ream holes - coordinate method.	M
8. Locate and bore holes - coordinate method.	M
9. Step drilling holes accurately to size.	P
10. Locate and mill a slot or pocket.	P
11. Countersinking, counterboring and spotfacing.	A
12a. Mill a square on a workpiece.	M
12b. Mill a hexagon on a workpiece.	M
13. Machine flat surface using fly cutter.	P
14a. Drill and ream equally spaced holes on a bolt circle using direct indexing.	P
14b. Drill and ream equally spaced holes on a bolt circle using simple indexing.	P
15. Mill a part using tracer unit.	M
16. Mill multi-level surfaces accurately.	P
17. Mill a fillet corner with a ball mill.	M
18. Machine a taper or wedge using a tilting table.	M
21. Tap holes on the vertical mill using a tapping attachment.	M
23. Drill holes using a drill jig.	M

* *Sample too small to validate.*

Appendix 9

PSYCHOMOTOR SKILL LIST - MACHINE TOOL OPERATOR, GENERAL

SKILL LEVEL: Articulation = A Precision = P Manipulation = M

Psychomotor Skill Task Number and Description	Skill level	Number performing the skill task	Student learning standard (minutes)	Number performing to standard +15%	% Meeting students learning standards within +15%	Valid
DO-ALL SAW I						
1. Coutour saw operation control familiarity.	P	4	21.4	4	100%	*
2. Butt weld a blade.	M	37	15.0	21	57%	No
3. Mount up a set of saw guides.	M	2	32	2	100%	*
4. Mount and remove a saw band.	P	1	15	1	100%	*
DRILLING MACHINE I						
1. Drill press operational control familiarity.	A	55	25	50	91%	Yes
2. Sharpen a drill by hand.	P	19	20	17	90%	Yes
3. Mount and hold work on the drill press.	P	8	45	8	100%	Yes
GRINDING MACHINES I						
1. Bench or floor type grinder operation control familiarity.	A	53	15	45	85%	Yes
3. Dressing a floor type grinding wheel.	P	21	22	19	91%	Yes
HORIZONTAL MILLING MACHINE I						
2. Install arbor in the spindle.	M	11	11.25	9	82%	Yes
3. Install a cutter on the arbor.	M	1	10.00	1	100%	*
6. Straddle mill a part clamped to table.	M	1	110	1	100%	*

Appendix 9 (continued)

Psychomotor Skill Task Number and Description	Skill level	Number performing the skill task	Student learning standard (minutes)	Number performing to standard +15%	% Meeting students learning standards within +15%	Valid
LATHES I						
1. Grinding a right hand turning tool.	A	65	180	65	100%	Yes
2. Lathe operator control familiarity	A	56	36.4	51	91%	Yes
3. Install and remove chucks and face plates - cam lock.	M	83	40	82	99%	Yes
4. Install and remove chucks and face plates - thr'd nose.	M	48	40	46	96%	Yes
5. Install and remove chucks and face plates - taper key.	M	45	40	45	100%	Yes
6. Rough centering in a 4-jaw chuck.	P	103	13	65	63%	No
7. Facing in a chuck.	A	124	46	101	82%	Yes
8. Center drilling in chucks and collets.	A	122	19	93	76%	No
9. Alignment of lathe centers.	M	103	40	91	88%	Yes
10. Mounting work between centers.	M	94	35	86	92%	Yes
11. Straight turning between centers.	M	98	87	88	90%	Yes
12. Knurling.	M	100	58.5	91	91%	Yes
13. Taper cutting - offset method.	M	83	94.2	76	92%	Yes
14. Straight turning work in a chuck.	A	70	53.5	40	57%	No
15. Precision centering in a 4-jaw chuck.	M	65	25	49	75%	No
16. Cutting steep tapers and chamfers.	A	67	83.3	62	93%	Yes
17. Drilling in a lathe.	A	70	62	62	89%	Yes
18. Reaming in a lathe.	A	65	62	65	100%	Yes
19. Grooving and parting operations.	P	66	63.8	52	79%	Yes
20. Grind a 60° threading tool.	M	85	120	82	97%	Yes
21. Cutting external threads.	M	76	78	52	68%	No
22. Grinding a radius tool.	M	35	180	34	97%	Yes
23. Grinding a round nose form tool.	M	28	180	28	100%	Yes
24. Radius and fillet turning.	P	31	50	16	52%	No

Appendix 9 (continued)

Psychomotor Skill Task Number and Description	Skill level	Number performing the skill task	Student learning standard (minutes)	Number performing to standard +15%	% Meeting students learning standards within +15%	Valid
25. Boring in an engine lathe.	A	28	78	22	79%	Yes
26. Cutting internal threads.	M	14	67	7	50%	No
27. Center drilling work between centers.	M	3	10	3	100%	*
28. Grinding a right hand facing tool.	M	3	60	3	100%	*
29. Facing work to length between centers.	M	6	48	6	100%	*
30. Taper turning - taper attachment.	M	10	86.3	8	80%	Yes
31. Tapping threads in a lathe.	P	14	67	12	86%	Yes
32. Mounting, facing and turning work on a mandrel	M	7	84	7	100%	*
38. Using a steady rest.	M	2	25.5	1	50%	*
LAYOUT AND BENCH WORK I						
1. Rough layout.	P	6	42	2	33%	*
3. Sawing with hand hack saw.	M	15	23	15	100%	Yes
4. Straight and draw filing.	M	11	49	5	46%	No
6. Cutting threads by hand with taps.	M	11	18	10	91%	Yes
8. Hand methods of removing broken studs.	M	1	50	1	100%	*
9. Cutting threads by hand with dies.	M	3	18	3	100%	*
MEASUREMENT I						
1. Measure with steel rule.	A	8	40	6	75%	No
2. Measure with outside micrometer.	A	55	3.75	10	18%	Yes
3. Measure with vernier caliper.	A	33	22.5	27	82%	Yes
5. Measure with small hole gages.	A	2	4.9	0	0	*
6. Measure with a telescoping gage.	P	1	4.05	0	0	*
8. Measure with depth mike.	A	6	3.3	2	33%	*
11. Measuring with a dial indicator.	A	15	10	3	20%	No

Appendix 9 (continued)

Psychomotor Skill Task Number and Description	Skill level	Number performing the skill task	Student learning standard (minutes)	Number performing to standard +15%	% Meeting students learning standards within 15%	Valid
POWER HACK SAW I						
1. Power hack saw operational control familiarity.	M	34	40	34	100%	Yes
2. Install hack saw blade.	M	46	20	44	96%	Yes
3. Cut off stock in the power hack saw.	P	41	30	40	98%	Yes
VERTICAL MILLING MACHINE I						
1. Vertical milling operational control familiarity.	M	6	33.9	1	17%	*
2. Chuck end mill in collet in spindle.	M	4	22	2	50%	*
3. Align spindle perpendicular to table.	P	10	75	10	100%	Yes
4. Mount and align a vise to the table.	A	24	23	13	54%	No
5. Square a piece of work clamped to the table.	P	1	90	1	100%	*
6. Square work held in a vise.	A	25	60	13	52%	No
7. Locate, drill and ream holes - coordinate method.	M	17	292	16	94%	Yes
8. Locate and bore holes - coordinate method.	M	14	330	11	79%	Yes
10. Locate and mill a slot or pocket.	P	5	250	4	80%	*
11. Countersinking, counterboring and spotfacing.	A	3	225	2	67%	*
13. Machine flat surface using fly cutter.	P	2	60	2	100%	*
14b. Drill and ream equally spaced holes on a bolt circle using simple indexing.	P	1	160	0	0	*
17. Mill a fillet corner with a ball mill.	M	1	60	1	100%	*

Appendix 10

TENTATIVE ARTICULATED GUIDE

MACHINE SHOP

DIVISION OF VOCATIONAL/TECHNICAL EDUCATION
STATE BOARD FOR VOCATIONAL EDUCATION

June, 1977

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INTRODUCTION

The format of this guide is intended to make it useful to any machine shop instructor in preparing students for careers in the machine shop occupational cluster. It is intended to allow instructors flexibility, but, at the same time, allow articulation between all machine shop programs in the state.

Articulation is attained because the same objectives with the same criteria of accomplishment will be used by all machine shop instructors across the state and therefore attainment of any objective at any level means the same thing in every shop. This guide allows flexibility because the objectives are described in terms of classes of equipment rather than being written for specific makes or models of equipment. Whatever equipment, which is both adequate for the skill described and available to the student, is suitable for instructional purposes.

Each student's progress can be recorded on a "tracking" form, and this form can be transferred with the student to any other machine shop program in Utah. The new instructor will know exactly what the student has accomplished and where to start him/her with additional machine shop skill training.

It is our sincere hope that you find this guide practical and useful.

Committee: Frank Boulton
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PSYCHOMOTOR SKILL TRAINING

The performance of psychomotor skills is key to nearly all vocational training. Students learn these skills most efficiently through hands-on experience in the shop. R.H. Dave, in an article entitled, "Systems of Curriculum Development," in Industrial Education, October, 1973, p. 23, categorizes skill development into five levels. He proposes that learning of skills occurs in a constant sequence in which the learner achieves a particular degree of attainment at Imitation, Manipulation, Precision, and Articulation before the ultimate Naturalization can be reached.

Level 1. Imitation

Description of this psychomotor skill level:
When the learner is exposed to an observable action, he begins to make covert imitation of that action. Such covert behavior appears to be the starting point in the growth of psychomotor skill. This is then followed by overt performance of an act and the capacity to repeat it. The performance, however, lacks neuromuscular coordination or control, and hence is generally in a crude and imperfect form (i.e. impulse, over repetition).

Teacher's role:
To cause imitation learning, the teacher must provide demonstrations of the skill. Live teachers provide the best demonstrations, but those same demonstrations can be available on film or video-tape in order to be accessible to learners operating in individualized, open-shop situations.

Student's role:
Imitation level psychomotor skill development occurs when the student is free to imitate while observing accurate and correct skill demonstration.

Related knowledge needed by the student:
Most students in vocational programs have adequate cognitive development to perform at the imitation level.

Level 2. Manipulation

Description of this psychomotor skill level:
Manipulation level skill attainment involves performance of the skill according to a specific set of instructions available during the performance. No specific criteria of quality are to be imposed.

Teacher's role:

The teacher must provide the specific set of instructions that guide the student through the performance of the skill. The instructions may be written, audiotape, or verbal. The instructions may be controlled by the learner, as in written or audiotape instructions, or may be provided by a teacher serving as a continuous coach using a fixed sequence of verbal instructions. Advanced students can also effectively provide this coaching.

Student's role:

A student has performed at the manipulation psychomotor skill level when he/she completes the skill act in one continuous operation without coaching aside from the specific instruction set. The manipulation level has no criteria for quality; simple completion of the task without special assistance is sufficient.

Related knowledge needed by the student:

In order for a learner to follow a set of specific instructions, the appropriate elements of discriminated recall must be acquired. This means that the student must learn the technical terminology related to the specific process and equipment on which the skill is to be performed.

Level 3. Precision

Description of this psychomotor skill level:

The precision level of skill attainment is characterized by performance of the skill with instructions available for reference but not followed step-by-step, and with performance that attains one form of quality. The precision level criteria of success may be time or accuracy or appearance or functionability, but only one criterion of quality at a time. The quality criterion of "accuracy" seems most appropriate for machine shop skills and has been selected for this guide.

Teacher's role:

The teacher must provide the opportunity to practice using a reference set of instructions until the industry standard of "accuracy" can be attained. He then must provide feedback when needed, to verify the quality attained, and to explain how and why the learner should adjust skill performance in order to attain or improve accuracy.

Student's role:

The student has performed at the precision psychomotor skill level when he/she can complete a skill without more than occasional reference to detailed instructions and the skill is performed to the industry "accuracy" standard. This level of performance requires repetition of the skill activity until the industry standard for "accuracy" is achieved.

Related knowledge needed by student:

The transition in skills from the following of a detailed set of instructions in manipulation to precision performance almost independent of the set of instructions, requires understanding of the how and why of some elements of the performance. Thus, some concept learning must preceed and some concept learning must accompany acquisition of precision level skills. The shop, where the hands can be used in learning, is the optimum place to learn concepts, and the optimum time to learn concepts is when you need them in order to go or.

Level 4. Articulation

Description of this psychomotor skill level:

Articulation level psychomotor skill attainment is characterized by either concurrent performance of two skills to precision standards or performance of one skill to two precision quality standards simultaneously.

The learner must solve the problem of how to adjust his performance to assure both forms of quality rather than sacrifice one for the other. The quality criterion of "accuracy" and "time" seem appropriate for machine shop skills and have been selected for use with this guide.

Teacher's role:

The role of the teacher shifts to that of the master, analogous to the traditional master/apprentice relationship. No formal set of instructions will be sufficient. Both master and learner must closely observe the performance and jointly select fine modifications which will alter performance appropriately. Additional skill practice must be provided the student until skill performance meets two standards: "accuracy" and "time".

Student's role:

The student has performed at the articulation level when he/she can complete a skill to the

industry standards for "accuracy" and "time" simultaneously. The student should repeat the skill activity until the quality criteria are met.

Related knowledge needed by student:
Articulation psychomotor skill performance requires adjusting the separate precision level skills so that combinations can succeed at multiple quality levels concurrently. Unless the principles governing attainment of quality are understood, the successful adjustments will be selected almost accidently, and no basis for application to new situations will be established. If we teach application of principles as part of precision skill attainment then learners will be able to appropriately adjust and account for the effects of adjustment in each new situation; then acquisition of articulation level skills will be possible, and the rate of learning will be proportional to the facility of application of principles. The role of the teacher is that of aiding the student to perceive which principles govern the situation and which other principles share significant elements and are therefore concurrently adjustable.

Level 5. Naturalization

Description of this psychomotor skill level:
Naturalization requires a high level of proficiency in the skill performance of a single act. The behavior is performed with the least expenditure of psychic and physical energy. The act is routinized to such an extent that it results in automatic and spontaneous response (i.e. performance becomes natural and smooth).

We have concluded that articulation is the highest skill which we can afford to teach in schools. Naturalization, or the performance of complex combinations of skills with minimum expenditure of psychic and physical energy requires time and experience beyond the resources of public schools.

MACHINE SHOP ARTICULATION, PRECISION, AND MANIPULATION SKILLS

Feedback from many industry contacts indicate that present vocational programs do not adequately prepare students to enter careers and perform at an industry level without significant time developing necessary speed in skill performance. This is because present training programs train the students to perform skills at the "precision" or "manipulative" levels of psychomotor development while the industry standard is skill performance at the "articulation" level of psychomotor development. This means that skill learning units used in vocational courses must contain real, legitimate industry-based "accuracy" and "time" standards so that student performance at the articulation level of psychomotor skill development can be measured and certified.

The state course of study in machine shop contains more than 160 psychomotor skills. It is impossible to train students to articulation skill performance in all 160 skills in the normal laboratory time offered in schools in less than four years. We, therefore, used Pareto's Law as a guide in finding the vital few skills among the many skills which should be taught. Pareto, an economist, found that there is a normal, natural maldistribution between causes and effects that could be described mathematically. Ordinarily, he noted, things distribute themselves in a 20 to 80 ratio--that is, 80 percent of the effects can be attributed to 20 percent of the possible causes. According to his law, for example, about 20 percent of the employees will account for 80 percent of the absenteeism, or 20 percent of a firm's inventory items will create 80 percent of the problems. Knowledge of this principle allowed us to concentrate on identifying the vital 20 percent of skills which are critical to job performance. It is our firm belief that this principle applies in terms of the skill tasks employees perform in their jobs. That is, 20 or 30 percent of the total number of skill tasks required for an employee in a skill position will take 70 to 80 percent of his/her time on the job. Another 15 to 20 percent of the skills would, according to Pareto, take 15 to 20 percent of the employee's time on the job. The remaining 50 to 60 percent of the skills would be used only 10 to 15 percent of the job time.

A survey form containing 163 machine shop skills listed in the State Guide was developed. Fifteen Wasatch Front companies specializing in machine shop work or having machine shops as part of their operations were identified and visited by a member of our survey team. More than 60 machine tool operators and their foremen supplied data for the survey. Specifically, they were asked to identify:

1. The skill tasks that were used daily (or at least three times per week) by machine tool operators in their shop.

2. The skill tasks used weekly (once or twice per week) by their machine tool operators, and

3. The skill tasks used monthly (fewer than 2 or 3 times per month) by their machine tool operators.

It was determined that those skills used essentially on a daily basis would be classified as articulation level psychomotor skills. If Pareto's Law is true in this situation, some 20 to 30 percent of the total number of skills would fit this category. A new employee who could perform these skills at the articulation level would be fully productive 70 to 80 percent of his/her time on the job.

If the skills were used essentially on a weekly basis, it would be less important for the beginning employee to be able to perform at the full industry standard (articulation level). These less frequent tasks could be practiced on the job to acquire whatever speeds were necessary so long as the employee could work to sufficient accuracy. Application of Pareto's rule provides prediction that 15 to 20 percent of the machine shop skills should fit this classification. In this guide we have identified those skills for training to the precision level since accuracy is necessary but concurrent speed is significantly less important.

Skills used only a few times a month have been classified for attainment of manipulation level skill only. Certainly the new employee should have "done it" properly at least once before encountering it on the job, but if the skills which occupy 80 to 90 percent of the job have been adequately developed, both the employee and employer can afford some carefully guided practice on these seldom encountered skills. We anticipate that 50 to 60 percent of the listed skills would fall into this category, but the same skills would occupy less than ten percent of job time.

The data from the survey were tabulated with these results:

Articulation	25 skills	(17 percent)
Precision	33 skills	(23 percent)
Manipulation	89 skills	(60 percent)

Machine Tool Operator General

The anticipated beginning employment level for most vocational students in machine shop programs is that described in the Dictionary of Occupational Titles as "Machine Tool Operator, General":

> Sets up and operates two or more types of machine tools, such as lathes, milling machines, boring machines, and grinders, to machine metal workpieces according to specifications, tooling instructions, standard charts, applying knowledge

of machining methods: Reads blueprint or job order for product specifications, such as dimensions and tolerances, and tooling instructions, such as fixtures, feed rates, cutting speeds, depth of cut, and cutting tools to be used. Positions and secures workpiece to holding device, machine table, chuck, centers, or fixture, using clamps and wrenches. Positions and secures tool in toolholder (chuck, collet, or toolpost). Moves controls to position tool and workpiece in relation to each other, and to set specified feeds, speeds, and depth of cut. Starts machine, turns handwheel to feed tool to workpiece or vice versa, and engages feed. Turns valve handle to direct flow of coolant or cutting oil against tool and workpiece. Observes operation, and verifies conformance of machined workpiece to specifications, using measuring instruments, such as fixed gages, calipers, and micrometers.

Based on this job description, a machine shop student trained to the articulation level in the identified 25 skills will be fully productive 70 to 80 percent of his/her time in this job classification. If the precision skills are accomplished at that level, the student will be adequately productive during 80 to 90 percent of time spent on the job. The articulation and precision level psychomotor skills should be those emphasized in our machine shop training programs.

Attachment 1

PSYCHOMOTOR SKILL LIST - MACHINE TOOL OPERATOR, GENERAL

SKILL LEVEL: Articulation = A Precision = P Manipulation = M

DO-ALL SAW I

		SKILL LEVEL
1.	Contour saw operation control familiarity.	P
2.	Butt weld a blade.	M
3.	Mount up a set of saw guides.	M
4.	Mount and remove a saw band.	P
5.	Mount and remove a file band.	M
6.	Sawing to layout lines.	M

DRILLING MACHINE I

1.	Drill press operational control familiarity.	A
2.	Sharpen a drill by hand.	P
3.	Mount and hold work on the drill press.	P
4.	Drill holes to layout lines.	M
5.	Drill holes through the center of round stock.	M
6.	Step drill holes accurately to size.	P
7.	Drill holes using a drill jig.	M
8.	Countersink, counterbore and spotface.	P
9.	Ream holes to size.	P
11.	Tap holes in drill press by hand.	P

GRINDING MACHINES I

1.	Bench or floor type grinder operation control familiarity.	A
3.	Dressing a floor type grinding wheel.	P
4.	Blanchard grinder operational control familiarity.	M
5.	Dress a blanchard grinding wheel.	M
6.	Blanchard grind part parallel and to size.	M
7.	Surface grinder operation control familiarity.	M
8.	Dress surface grinding wheel.	P
9.	Grind a part parallel and to size.	P
10a.	Remove and mount a surface grinding wheel.	M
10b.	Remove and mount a grinding wheel on tool & cutter grinder.	M
12.	Cylindrical grinder operational control familiarity.	M

GRINDING MACHINES (cont'd)

		SKILL LEVEL
13.	Dress cylindrical grinding wheel.	M
14.	Grind a cylindrical part between centers.	M
15.	Grind a tapered part between center points.	M
16.	Tool and cutter grinder operation control familiarity.	M
17.	Grinding a cutting tool to print or signature.	M

HORIZONTAL MILLING MACHINE I

1.	Operation control familiarity.	M
2.	Install arbor in the spindle.	M
3.	Install a cutter on the arbor.	M
4.	Slab mill a piece square held in a vise.	M
5.	Face mill a part clamped to table.	M
6.	Straddle mill a part clamped to table.	M
7.	Mount dividing head and foot stock.	M
8.	Cut teeth on a spur gear.	M
9.	Cut keyway in shaft with plain milling cutter.	M
13.	Machine an external radius.	M
14.	Mill an angular slot.	M
17.	Slit work held in vise.	M
23.	Mill multi-level surfaces.	M

LATHES I

1.	Grinding a right hand turning tool.	A
2.	Lathe operator control familiarity.	A
3.	Install and remove chucks and face plates - cam lock.	M
4.	Install and remove chucks and face plates - thr'd nose.	M
5.	Install and remove chucks and face plates - taper key.	M
6.	Rough centering in a 4-jaw chuck.	P
7.	Facing in a chuck.	A
8.	Center drilling in chucks and collets.	A
9.	Alignment of lathe centers.	M

LATHES I (cont'd)	SKILL LEVEL
10. Mounting work between centers.	M
11. Straight turning between centers.	M
12. Knurling.	M
13. Taper cutting - offset method.	M
14. Straight turning work in a chuck.	A
15. Precision centering in a 4-jaw chuck.	M
16. Cutting steep tapers and chamfers.	A
17. Drilling in a lathe.	A
18. Reaming in a lathe.	A
19. Grooving and parting operations.	P
20. Grind a 60° threading tool.	M
21. Cutting external threads.	M
22. Grinding a radius tool.	M
23. Grinding a round nose form tool.	M
24. Radius and fillet turning.	P
25. Boring in an engine lathe.	A
26. Cutting internal threads.	M
27. Center drilling work between centers.	M
28. Grinding a right hand facing tool.	M
29. Facing work to length between centers.	M
30. Taper turning - taper attachment.	M
31. Tapping threads in a lathe.	P
32. Mounting, facing and turning work on a mandrel.	M
33. Rough and finish turning using cemented carbides and ceramics.	P
35a. Changing jaws in a 4-jaw independent chuck.	M
35b. Changing the jaws in a 3-jaw universal chuck with a set of inside and outside jaws.	M
35c. Reversing the jaws in a 3-jaw universal chuck with cap screw mounted jaws.	M
36. Machining a part with a tracing attachment.	M
37. Reaming a tapered hole.	M
38. Using a steady rest.	M

LAYOUT AND BENCH WORK I	SKILL LEVEL
1. Rough layout.	P
2. Precision layout.	P
3. Sawing with hand hack saw.	M
4. Straight and draw filing.	M

LAYOUT AND BENCH WORK I (cont'd)	SKILL LEVEL
5. Sizing holes with hand reamers.	M
6. Cutting threads by hand with taps.	M
7. Hand methods of deburring parts.	A
8. Hand methods of removing broken studs.	M
9. Cutting threads by hand with dies.	M
15. Center drilling in center drilling machine.	M

MEASUREMENT I	
1. Measure with steel rule.	A
2. Measure with outside micrometer.	A
3. Measure with vernier caliper.	A
4. Measure with inside mike.	A
5. Measure with small hole gages.	A
6. Measure with a telescoping gage.	P
7. Measure with a depth rule.	M
8. Measure with depth mike.	A
9. Measure with depth vernier.	M
10. Measuring with protractors.	P
11. Measuring with a dial indicator.	A
12. Measuring angles and taper with a sine plate.	M
13. Measure with dial bore gages.	A
14. Measure with intra-micrometers.	P
15. Measure with radius gages.	A
16. Measure with optical comparator.	M
17. Measuring with thread micrometers.	M
18. Measure thread pitch dia. (GO, No-Go).	A
19. Check concentricity (center and indicator).	P
21. Measuring with a thread plug gage.	P
22. Measure hardness of metal with a Rockwell Hardness tester.	M
23. Measuring with the toolmakers microscope.	M
24. Check hole location by coordinate method (surface plate setup).	M
25. Check hole location by true position method.	M
26. Check precision square for squareness with cylindrical square.	M
27. Check squareness with a precision square.	P

MEASUREMENT I (cont'd)	SKILL LEVEL
28. Checking surface finish with a surface comparator gage.	M
29. Measure hole dia. with deltronic pins.	M

POWER HACK SAW I	
1. Power hack saw operational control familiarity.	M
2. Install hacksaw blade.	M
3. Cut off stock in the power hack saw.	P

VERTICAL MILLING MACHINE I	
1. Vertical milling operational control familiarity.	M
2. Chuck end mill in collet in spindle.	M
3. Align spindle perpendicular to table.	P
4. Mount and align a vise to the table.	A
5. Square a piece of work clamped to the table.	P
6. Square work held in a vise.	A
7. Locate, drill and ream holes - coordinate method.	M
8. Locate and bore holes - coordinate method.	M
9. Step drilling holes accurately to size.	P
10. Locate and mill a slot or pocket.	P
11. Countersinking, counterboring and spotfacing.	A
12a. Mill a square on a workpiece.	M
12b. Mill a hexagon on a workpiece.	M
13. Machine flat surface using fly cutter.	P
14a. Drill and ream equally spaced holes on a bolt circle using direct indexing.	P
14b. Drill and ream equally spaced holes on a bolt circle using simple indexing.	P
15. Mill a part using tracer unit.	M
16. Mill multi-level surfaces accurately.	P
17. Mill a fillet corner with a ball mill.	M
18. Machine a taper or wedge using a tilting table.	M
21. Tap holes on the vertical mill using a tapping attachment.	M

VERTICAL MILLING MACHINE I (cont'd)	SKILL LEVEL
23. Drill holes using a drill jig.	M

MACHINE TOOL OPERATOR, GENERAL:

TASK #	TASK DESCRIPTION	PERFORMANCE OBJECTIVE	PERFORMANCE CRITERIA
DO-ALL SAW I:			
1	Contour saw operation control familiarity	Given a Do-All saw with accessories, the student will operate the saw to the specified performance criteria.	Accuracy - the saw will be operated to the instructor's satisfaction. Time - operation of the saw will be done to industry standard.
2	Mount and remove a file band on the Do-All saw	Given a Do-All band saw and a file band, the student will mount and remove the file band to the specified performance criteria.	Accuracy - the file band will be mounted to the instructor's satisfaction. Time - the operation will be performed to the industry standard.
3	Butt weld a saw band	Given a Do-All saw with welding attachment and a length of band blade, the student will weld the butt ends to the specified performance criteria.	Accuracy - the saw band weld must withstand a specified bend test and fit the saw guides. Time - the weld will be done to the industry standard.
4	Mount a set of saw guides	Given a Do-All saw and a set of saw guides, the student will mount the guides to the specified performance criteria.	Accuracy - a gauge should fit the specific saw guides after mounting. Time - the operation will be performed to the industry standard.
5	Mount and remove a saw band on the Do-All saw	Given a Do-All band saw and a welded band, the student will mount and remove the band to the specified performance criteria.	Accuracy - the band will be mounted to the instructor's satisfaction. Time - the operation will be performed to the industry standard.
6	Saw to layout lines on Do-All band saw	Given a Do-All band saw and accessories, a saw band, and a workpiece, the student will saw the layout lines to the specified performance criteria.	Accuracy - the saw cuts will be such that all layout lines are visible and the cut surface will have a 250 microinch surface finish or better.

TASK #	TASK DESCRIPTION	PERFORMANCE OBJECTIVE	PERFORMANCE CRITERIA
DO-ALL SAW I (cont'd):			
			Time - the operation will be performed to the industry standard.
DRILLING MACHINE I:			
1	Drilling machine operation control familiarity	Given a drill press with accessories, the student will operate the drill press to the specified performance criteria.	Accuracy - the drill press will be operated to the satisfaction of the instructor. Time - operation of the drill press will be performed to the industry standard.
2	Sharpen a drill on a bench or pedestal grinder	Given a bench or pedestal grinder and a dulled drill, the student will sharpen the drill to the specified performance criteria.	Accuracy - the drill angles will be within 2° of the correct angles; the lip length will be within 1/64" of each other. Time - the operation will be performed to the industry standard.
3	Mount and hold work on the drill press	Given a drill press and accessories, clamp set, vise, c-clamps, parallels, V-block angle plate, and several workpieces, the student will make each set-up to the specified performance criteria.	Accuracy - Each set-up will be made to the instructor's satisfaction. Time - the operation will be performed to the industry standard.
4	Drill holes to layout lines	Given a drill press and accessories and a workpiece with holes laid out for drilling, the student will drill the holes to the specified performance criteria.	Accuracy - the prick punch marks around the layout will be visible; the surface finish will be 125 microinches or better. Time - the operation will be performed to the industry standard.
5	Drill holes through the center of round stock	Given a drill press and accessories and a round workpiece, the student will drill the holes to the specified performance criteria.	Accuracy - the holes will be drilled to ± .002 size and ± .005 location; the surface finish will be 125 microinches or better. Time - the operation will be performed to the industry standard.

TASK #	TASK DESCRIPTION	PERFORMANCE OBJECTIVE	PERFORMANCE CRITERIA
DRILLING MACHINE I (cont'd):			
6	Step drill holes accurately to size	Given a drill press and accessories, several specific drills, drill vise, and a workpiece, the student will step drill holes to the specified performance criteria.	Accuracy - the holes will be drilled to ± .003" accuracy with a surface finish of 125 microinches or better. Time - the operation will be performed to the industry standard.
7	Drill holes using a drill jig	Given a drill press, drill jig, several drills, and a workpiece, the student will drill holes while workpiece is held in jig to the specified performance criteria.	Accuracy - the holes will be drilled to hole location and size dimensions within ± .002" with a surface finish of 125 microinches or better. Time - the operation will be performed to the industry standard.
8	Countersink, counterbore and spotface in a drill press	Given a drill press and accessories, countersink, counterbore and spotface tools, and a workpiece, the student will countersink, counterbore, and spotface to the specified performance criteria.	Accuracy - The countersink, counterbore and spotface dimensions will be accurate to ± 1/64" and the surface finish 125 microinches or better. Time - the countersink, counterbore and spotface will be done to the industry standard.
9	Ream holes to size in drill press	Given a drill press and accessories, a series of reamers, and a workpiece, the student will ream holes to the specified performance criteria.	Accuracy - the holes will be reamed $^{+.002}_{-.000}$ inches accuracy with a surface finish of 63 microinches or better. Time - the holes will be reamed to the industry standard.
11	Tap holes in a drill press by hand	Given a drill press, vise, tap wrench, tap, and a workpiece, the student will tap holes to the specified performance criteria.	Accuracy - the threads will be correct as checked by a class 2 Go-NoGo thread plug gage. Time - the threads will be tapped to the industry standard.

TASK #	TASK DESCRIPTION	PERFORMANCE OBJECTIVE	PERFORMANCE CRITERIA
GRINDING MACHINE I:			
1	Balder bench or pedestal grinder operation control familiarity	Given a Balder bench or pedestal grinder, the student will operate the grinder to the specified performance criteria.	Accuracy - the grinder will be operated to the satisfaction of the instructor. Time - the grinder will be operated to the industry standard.
3	Dressing and truing a grinding wheel on a pedestal grinder	Given a pedestal grinder and wheel dresser, the student will dress the wheel to the specified performance criteria.	Accuracy - all dull grains will be removed, all foreign material will be removed, and the wheel must run true. Time - the operation will be done to the industry standard.
4	Blanchard vertical spindle surface grinder operation control familiarity	Given a Blanchard vertical spindle grinder, the student will operate the grinder to the specified performance criteria.	Accuracy - the grinder will be operated to the satisfaction of the instructor. Time - the operation will be performed to the industry standard.
5	Dressing the Blanchard vertical spindle surface grinding wheel	Given a Blanchard vertical spindle grinder and a wheel dresser, the student will dress the wheel to the specified performance criteria.	Accuracy - all dull, glazed and loaded particles will be removed from the wheel and the wheel will run true with its axis. Time - the operation will be performed to the industry standard.
6	Grind a part parallel and to size on the Blanchard vertical spindle surface grinder	Given a Blanchard vertical spindle surface grinder and a workpiece, the student will grind the workpiece parallel and to size to the specified performance criteria.	Accuracy - the workpiece will be ground parallel and to size within ± .010". Time - the operation will be performed to the industry standard.
7	Surface grinder operation control familiarity - B & S #618	Given a B & S surface grinder, the student will operate the grinder to the specified performance criteria.	Accuracy - the grinder will be operated to the satisfaction of the instructor. Time - the operation will be performed to the industry standard.

TASK #	TASK DESCRIPTION	PERFORMANCE OBJECTIVE	PERFORMANCE CRITERIA
GRINDING MACHINE I (cont'd):			
8	Dress the surface grinding wheel	Given a surface grinder and wheel dresser, the student will dress the wheel to the specified performance criteria.	Accuracy - the dull, glazed and loaded particles will be removed and the wheel will run true to its axis. Time - the operation will be performed to the industry standard.
9	Grind a part parallel and to size	Given a surface grinder and a workpiece, the student will grind the part parallel and to size to the specified performance criteria.	Accuracy - the workpiece will be ground parallel and to size within .0002" with a 8 microinch surface finish or better. Time - the operation will be performed to the industry standard.
10a	Remove and mount a grinding wheel on the surface grinder	Given a surface grinder and a grinding wheel, the student will remove and mount a grinding wheel to the specified performance criteria.	Accuracy - the wheel will be removed and mounted to the instructor's satisfaction. Time - the operation will be performed to the industry standard.
10b	Remove and mount a grinding wheel on the tool and cutter grinder	Given a tool and cutter grinder and a grinding wheel, the student will remove and mount a wheel to the specified performance criteria.	Accuracy - the wheel will be removed and mounted to the satisfaction of the instructor. Time - the operation will be performed to the industry standard.
12	Morora cylindrical grinder operation control familiarity	Given a Morora cylindrical grinder, the student will operate the grinder to the specified performance criteria.	Accuracy - the grinder will be operated to the satisfaction of the instructor. Time - the operation will be performed to the industry standard.
13	Dressing the grinding wheel on a cylindrical grinder.	Given a cylindrical grinder and a wheel dresser, the student will dress the wheel to the specified performance criteria.	Accuracy - the dull, glazed and loaded particles will be removed and the wheel run true to its axis. Time - the operation will be performed to the industry standard.

TASK #	TASK DESCRIPTION	PERFORMANCE OBJECTIVE	PERFORMANCE CRITERIA
GRINDING MACHINE I (cont'd):			
14	Grinding a cylinder between centers	Given a cylindrical grinder and workpiece, the student will grind the workpiece to the specified performance criteria.	Accuracy - the diameters of the workpiece will be ground to ± .0002" in size and a surface finish of 16 microinches or better. Time - the operation will be performed to the industry standard.
15	Grind a tapered part between centers	Given a cylindrical grinder and workpiece, the student will grind the workpiece to the specified performance criteria.	Accuracy - the diameters will be held to .002" with a surface finish of 16 microinches or better. Time - the operation will be performed to the industry standard.
16	Tool and cutter grinder operation control familiarity (Cincinnati)	Given a tool and cutter grinder, the student will operate the grinder to the specified performance criteria.	Accuracy - the grinder will be operated to the satisfaction of the instructor. Time - the operation will be performed to the industry standard.
17	Grinding a cutting tool to print	Given a tool and cutter grinder and a tool bit blank, the student will grind the blank to the specified performance criteria.	Accuracy - the angles will be ground to ± 1". Time - the operation will be performed to the industry standard.
HORIZONTAL MILLING MACHINE I:			
1	Horizontal mill operating center familiarity (Milwaukee, Model H)	Given a horizontal mill, the student will operate the mill to the specified performance criteria.	Accuracy - the mill will be operated to the satisfaction of the instructor. Time - the operation will be performed to the industry standard.
2	Install an arbor in the mill spindle	Given a horizontal mill and a type B arbor, the student will install the spindle to the specified performance criteria.	Accuracy - the spindle will be installed to the satisfaction of the instructor.

TASK #	TASK DESCRIPTION	PERFORMANCE OBJECTIVE	PERFORMANCE CRITERIA
HORIZONTAL MILLING MACHINE I (cont'd):			
			Time - the operation will be performed to the industry standard.
3	Install a plain milling cutter on the milling machine arbor	Given a horizontal mill, a milling arbor, and plain milling cutter, the student will install the cutter to the specified performance criteria.	Accuracy - the milling cutter will be installed on the arbor to the satisfaction of the instructor. Time - the operation will be performed to the industry standard.
4	Squaring a piece of stock held in a vise	Given a horizontal mill, milling arbor, slab mill, vise and a workpiece, the student will mill the workpiece to the specified performance criteria.	Accuracy - the four milled surfaces shall be square within .010" of each other with a surface finish of 125 microinches or better. Time - the operation will be performed to the industry standard.
5	Face mill a part clamped to the table	Given a horizontal mill, clamp set, face mill, and a workpiece, the student will face mill the workpiece to the specified performance criteria.	Accuracy - the ends of the workpiece should be milled square within .005" with a surface finish of 125 microinches or better. Time - the operation will be performed to the industry standard.
6	Straddle mill a part clamped to the table	Given a horizontal mill, arbor, clamp set, pair of side milling cutters and a workpiece, the student will mill the workpiece to the specified performance criteria.	Accuracy - the milled dimensions shall be held to ± .003" with a surface finish of 125 microinches or better. Time - the operation will be performed to the industry standard.
7	Mount the dividing head and footstock & align their centers	Given a horizontal milling machine, a dividing head and footstock, the student will mount the dividing head and footstock to the specified performance criteria.	Accuracy - the centers of the headstock and footstock will be parallel within .002". Time - the operation will be performed to the industry standard.

TASK #	TASK DESCRIPTION	PERFORMANCE OBJECTIVE	PERFORMANCE CRITERIA
HORIZONTAL MILLING MACHINE I (cont'd):			
8	Cut teeth on a spur gear with a dividing head	Given a horizontal mill, dividing head, and a workpiece, the student will cut a spur gear to the specified performance criteria.	Accuracy - the chordal thickness of the gear teeth will be held to ± .003". Time - the operation will be performed to the industry standard.
9	Cut a keyway in a shaft with a plain milling cutter	Given a horizontal mill, arbor, plain milling cutter, clamp set and a workpiece, the student will mill a keyway to the specified performance criteria.	Accuracy - the keyway dimensions will be held to ± .001". Time - the operation will be performed to the industry standard.
13	Machine an external radius	Given a horizontal mill, arbor, concave radius cutter and a workpiece, the student will cut a radius to the specified performance criteria.	Accuracy - the radius form will be held to ± .005". Time - the operation will be performed to the industry standard.
14	Mill an angular slot	Given a horizontal mill, arbor, double angle cutter and a workpiece, the student will machine an angular slot to the specified performance criteria.	Accuracy - the location dimensions of the slot will be held to ± .010", the angle to ± .1° and a surface finish of 125 microinches or better. Time - the operation will be performed to the industry standards.
17	Slit work held in a vise	Given a horizontal mill, arbor, vise, slitting saw, and workpiece, the student will mill a slot to the specified performance criteria.	Accuracy - the milled slot will be parallel to the edge and the dimensions will be within ± .002". Time - the operation will be performed to the industry standard.
23	Mill multi-level surfaces	Given a horizontal mill, arbor, vise, plain milling cutter and workpiece, the student will mill multi-level surfaces to the specific performance criteria.	Accuracy - the milled dimensions will be held to ± .002. Time - the operation will be performed to the industry standard.

TASK #	TASK DESCRIPTION	PERFORMANCE OBJECTIVE	PERFORMANCE CRITERIA
LATHES I:			
1	Grinding a right hand turning tool	Given a pedestal grinder and a piece of tool bit stock, the student will grind the tool bit to the specified performance criteria.	Accuracy - the angles will be ground to $\pm 2°$, the nose radius held to $+ 1/32$, $- 0$, and the tool bit not overheated. Time - the operation will be performed to the industry standard.
2	Lathe operating control familiarity (Pratt & Whitney, Clausing, Monarch, Graziano, South Bend, Roskelly, LeBlond and Rockwell)	Given a lathe, the student will operate the lathe to the specified performance criteria.	Accuracy - the lathe will be operated to the satisfaction of the instructor. Time - the operation will be performed to the industry standard.
3	Install and remove chucks and face plates (cam lock spindle)	Given a lathe and cam lock chuck and face plate, the student will install and remove them to the specified performance criteria.	Accuracy - the chuck and face plate will be installed and removed to the satisfaction of the instructor. Time - the operation will be performed to the industry standard.
4	Install and remove chucks and face plates (threaded nose)	Given a lathe and threaded chuck and face plate, the student will install and remove them to the specified performance criteria.	Accuracy - the chuck and face plate will be installed and removed to the satisfaction of the instructor. Time - the operation will be performed to the industry standard.
5	Install and remove chucks and face plates (tapered key type)	Given a lathe and tapered key chuck and face plate, the student will install and remove them to the specified performance criteria.	Accuracy - the chuck and the face plate will be installed and removed to the satisfaction of the instructor. Time - the operation will be performed to the industry standard.

TASK #	TASK DESCRIPTION	PERFORMANCE OBJECTIVE	PERFORMANCE CRITERIA
LATHES I (cont'd):			
6	Rough centering work in a 4-jaw chuck	Given a lathe, 4-jaw chuck and a workpiece, the student will center the workpiece to the specified performance criteria.	Accuracy - the workpiece will be centered to 1/32 of an inch to the axis of the lathe. Time - the operation will be performed to the industry standard.
7	Facing in a chuck	Given a lathe, chuck, tool post set-up, and a workpiece, the student will face the workpiece to the specified performance criteria.	Accuracy - the workpiece will be faced to ± 1/32" with a surface finish of 125 microinches or better. Time - the operation will be performed to the industry standard.
8	Center drilling in chucks and collets	Given a lathe, chuck, and a workpiece, the student will center drill the workpiece to the specified performance criteria.	Accuracy - the center drilled holes will be standard size ± 1/32" with a surface finish of 125 microinches or better. Time - the operation will be performed to the industry standard.
9	Align lathe centers	Given a lathe, lathe centers, dial indicator set-up and a testpiece, the student will align the centers to the specified performance criteria.	Accuracy - the centers should be aligned to .003" per foot. Time - the operation will be performed to the industry standard.
10	Mount workpieces between centers	Given a lathe, lathe centers and a workpiece, the student will mount the workpiece between centers to the specified performance criteria.	Accuracy - the workpiece shall be mounted to the satisfaction of the instructor. Time - the operation will be performed to the industry standard.
11	Straight turning between centers	Given a lathe, centers, tool post set-up and a workpiece, the student will do straight turning to the specified performance criteria.	Accuracy - the workpiece turned diameters will be held to ± .003" with 125 microinch surface finish or better.

TASK #	TASK DESCRIPTION	PERFORMANCE OBJECTIVE	PERFORMANCE CRITERIA
LATHES I (cont'd):			
			Time - the operation will be performed to the industry standard.
12	Knurling	Given a lathe, centers, knurling tool post set-up and a workpiece, the student will knurl the workpiece to the specified performance criteria.	Accuracy - the knurled surface must be a full diamond pattern without marring. Time - the operation will be performed to the industry standard.
13	Taper turning - tail stock offset method	Given a lathe, centers, tool post set-up and a workpiece, the student will turn a taper to the specified performance criteria.	Accuracy - the taper must be within .005" of the specified taper per foot with a surface finish of 125 microinches or better. Time - the operation will be performed to the industry standard.
14	Straight turning work held in a chuck	Given the lathe, chuck, tool post set-up and a workpiece, the student will do straight turning to the specified performance criteria.	Accuracy - the turned diameters will be ± .002" with a surface finish of 125 microinches or better. Time - the operation will be performed to the industry standard.
15	Precision centering work in a four jaw chuck	Given a lathe, 4-jaw chuck, indicator set-up, and a testpiece, the student will center the workpiece to the specified performance criteria.	Accuracy - the workpiece will be centered to .002" TIR. Time - the operation will be performed to the industry standard.
16	Cutting steep tapers and chamfers	Given a lathe, chuck, tool post set-up and a workpiece, the student will cut a steep taper and a chamfer to the specified performance criteria.	Accuracy - the angle of the taper will be within 1° of the specified angle with the surface finish 125 microinches or better. Time - the operation will be performed to the industry standard.

TASK #	TASK DESCRIPTION	PERFORMANCE OBJECTIVE	PERFORMANCE CRITERIA
LATHES I (cont'd):			
17	Drilling in a lathe	Given a lathe, tailstock drilling set-up and a workpiece, the student will drill holes to the specified performance criteria.	Accuracy - the hole diameters will be drilled to ± .010", the depth to ± 1/64" with a surface finish of 125 microinches or better. Time - the operation will be done to the industry standard.
18	Machine reaming in a lathe	Given a lathe, tailstock reaming set-up and a workpiece, the student will ream holes to the specified performance criteria.	Accuracy - the hole diameters will be reamed to $^{+.001}_{-.000}$ inches with a 63 microinch surface finish or better. Time - the operation will be done to the industry standard.
19	Parting and grooving operations in a lathe	Given a lathe, parting tool set-up and a workpiece, the student will part and groove to the specified performance criteria.	Accuracy - the parted face will be flat and square within .005" and the groove dimensions held to ± .005". Time - the operation will be performed to the industry standard.
20	Grinding a 60° threading tool	Given a piece of tool bit stock and a pedestal grinder, the student will grind the tool bit to the specified performance criteria.	Accuracy - the nose angle will beheld to ± 1°; all other angles will be held to ± 2°. Time - the operation will be performed to the industry standard.
21	Cutting external unified standard screw threads	Given a lathe, threading tool set-up and a workpiece, the student will cut threads to the specified performance criteria.	Accuracy - the thread will be cut to a unified class 2 specification. Time - the operation will be performed to the industry standard.
22	Grinding a radius tool	Given a lathe tool bit and a pedestal grinder, the student will grind a radius tool to the specified performance criteria.	Accuracy - the radius will fit the radius gage and the angles will be ground to ± 2°.

TASK #	TASK DESCRIPTION	PERFORMANCE OBJECTIVE	PERFORMANCE CRITERIA
LATHES I (cont'd):			
			Time - the operation will be performed to the industry standard.
23	Grinding a round nose form tool	Given a lathe tool bit and a pedestal grinder, the student will grind a form tool to the specified performance criteria.	Accuracy - the radius will fit the gage and the angles will be held to ± 2°. Time - the operation will be done to the industry standard.
24	Radius and fillet turning	Given a lathe, radius and fillet tools, tool post set-up and a workpiece, the student will machine radii and fillets to the specified performance criteria.	Accuracy - the machined radii and fillets must fit the radius or fillet gage within 1/64" and have a 63 microinch surface finish or better. Time - the operation will be performed to the industry standard.
25	Boring in a lathe	Given a lathe, boring tool post set-up and a workpiece, the student will bore holes to the specified performance criteria.	Accuracy - the holes will be bored to ± .002" with a 125 microinch surface finish or better. Time - the operation will be performed to the industry standard.
26	Cutting an internal unified standard screw thread	Given a lathe, thread boring tool post set-up and a workpiece, the student will bore threads to the specified performance criteria.	Accuracy - the thread must fit the unified class 2 thread gage. Time - the operation will be performed to the industry standard.
27	Center drilling work between centers	Given a lathe, drill chuck, lathe center and a workpiece, the student will center drill the workpiece to the specified performance criteria.	Accuracy - the center holes will be drilled to standard size ± 1/32" with a surface finish of 125 microinches or better. Time - the operation will be performed to the industry standard.

TASK #	TASK DESCRIPTION	PERFORMANCE OBJECTIVE	PERFORMANCE CRITERIA
LATHES I (cont'd):			
28	Grinding a right hand facing tool	Given a lathe tool bit and a pedestal grinder, the student will grind a right hand facing tool to the specified performance criteria.	Accuracy - the point angle will be held to ± 1°; all other angles to ±2°. Time - the operation will be performed to the industry standard.
29	Facing work to length between centers	Given a lathe, centers, tool post set-up and a workpiece, the student will face work to length to the specified performance criteria.	Accuracy - the length will be held to ± 1/32" with a 125 microinch surface finish or better. Time - the operation will be perfomed to the industry standard.
30	Taper turning in a lathe - taper attachment method	Given a lathe, taper attachment, tool post set-up and a workpiece, the student will machine a taper to the specified performance criteria.	Accuracy - the taper per inch will be within ± .002" to the standard with a 125 microinch surface finish or better. Time - the operation will be performed to the industry standard.
31	Tapping threads in a lathe	Given a lathe, chuck, tailstock tapping set-up and a workpiece, the student will tap a thread to the specified performance criteria.	Accuracy - the thread must fit the unified class 2 thread gages. Time - the operation will be performed to the industry standard.
32	Mount, face, and turn work on a mandrel	Given a lathe, face plate, centers, tool post set-up and a workpiece, the student will face and turn the workpiece to the specified performance criteria.	Accuracy - the workpiece will be faced to ± 1/32" length; the diameters turned to ± .003" with a 125 microinch surface finish or better. Time - the operation will be performed to the industry standard.
33	Rough and finish turning with carbides	Given a lathe, tool post set-up, carbide tool, chuck and a workpiece, the student will rough and finish turn the workpiece to the specified performance criteria.	Accuracy - the turned diameters will be held to ± .002" with a surface finish of 125 microinches or better. Time - the operation will be performed to the industry standard.

TASK #	TASK DESCRIPTION	PERFORMANCE OBJECTIVE	PERFORMANCE CRITERIA
LATHES I (cont'd):			
35a	Reverse the jaws in a 4-jaw independent chuck	Given a 4-jaw independent chuck, the student will reverse the jaws to the specified performance criteria.	Accuracy - the operation will be performed to the satisfaction of the instructor. Time - the operation will be performed to the industry standard.
35b	Change the jaws in a 3-jaw universal chuck	Given a 3-jaw chuck and a set of reverse jaws, the student will change the jaws to the specified performance criteria.	Accuracy - the operation will be performed to the satisfaction of the instructor. Time - the operation will be performed to the industry standard.
35c	Reversing the jaws in a 3-jaw universal chuck with cap screw mounted jaws	Given a 3-jaw chuck, the student will reverse the jaws to the specified performance criteria.	Accuracy - the jaws will be reversed to the satisfaction of the instructor. Time - the operation will be performed to the industry standard.
36	Machine a part with the tracing attachment	Given a lathe, tracing attachment, tool post set-up and a workpiece, the student will machine a workpiece using the tracer to the specified performance criteria.	Accuracy - the traced surfaces shall be within ± .010" of print dimensions with a surface finish of 250 microinches or better. Time - the operation will be performed to the industry standard.
37	Reaming a tapered hole	Given a lathe, chuck, tailstock reaming set-up and a workpiece, the student will taper ream a hole to the specified performance criteria.	Accuracy - the taper on the reamed hole will be within ± .002" to standard T.P.I. with a surface finish of 63 microinches or better. Time - the operation will be performed to the industry standard.
38	Using a steady rest	Given a lathe, tool post set-up, face plate, centers, steady rest and a workpiece, the student will do straight turning to the specified performance criteria.	Accuracy - the turned diameters will be held to ± .003" with a surface finish of 125 microinches or better. Time - the operation will be performed to the industry standard.

TASK #	TASK DESCRIPTION	PERFORMANCE OBJECTIVE	PERFORMANCE CRITERIA
LAYOUT AND BENCH WORK I:			
1	Rough layout of a workpiece	Given a combination square, scribe, calipers, prick punch, hammer, layout ink and a workpiece, the student will layout the workpiece to the specified performance criteria.	Accuracy - the layout lines will be within ± 1/64" of the dimensions. Time - the operation will be performed to the industry standard.
2	Precision layout of a workpiece	Given a height gage, precision angle plate, c-clamp, layout ink and a workpiece, the student will lay out the workpiece to the specified performance criteria.	Accuracy - the layout lines will be within ± .005" of the dimensions. Time - the operation will be performed to the industry standard.
3	Sawing stock with a hand hack saw	Given a hack saw, vise, and a piece of stock, the student will saw the stock to size to the specified performance criteria.	Accuracy - the layout lines must show with no more than 1/32" of stock outside the line. Time - the operation will be performed to the industry standard.
4	Straight and draw filing metal	Given appropriate files, file card, vise with soft jaws, and a workpiece, the student will file the workpiece to the specified performance criteria.	Accuracy - the filing operation will bring the dimensions to ± .015" of standard and final draw filing lines will show in one direction. Time - the operation will be performed to the industry standard.
5	Sizing holes with hand reamers	Given appropriate reamers, vise with soft jaws and a workpiece, the student will hand ream holes to the specified performance criteria.	Accuracy - the reamed holes shall be within ± .0005" with a surface finish of 32 micro-inches or better. Time - the operation will be performed to the industry standard.
6	Tapping threads by hand	Given a tap wrench, set of taps and a workpiece, the student will tap threads to the specified performance criteria.	Accuracy - the threads must fit the class 2 thread gages. Time - the operation will be performed to the industry standard.

TASK #	TASK DESCRIPTION	PERFORMANCE OBJECTIVE	PERFORMANCE CRITERIA
LAYOUT AND BENCH WORK I (cont'd):			
7	Hand methods of deburring parts	Given a file, 3 corner scraper, polishing stone, file card and a workpiece, the student will deburr the workpiece to the specified performance criteria.	Accuracy - all edges will be broken so that no burrs can be seen or felt. Time - the operation will be performed to the industry standard.
8	Hand methods of removing broken studs	Given the appropriate tools and workpieces, the student will remove broken studs to the specified performance criteria.	Accuracy - the whole stud must be removed without excessive damage to the thread. Time - the operation will be performed to the industry standard.
9	Cutting threads by hand using a die	Given a die set, bench vise with soft jaws, and a workpiece, the student will cut threads with a die to the specified performance criteria.	Accuracy - the threads must fit class 2 thread gages. Time - the operation must be performed to the industry standard.
15	Center drilling in center drilling machine	Given a center drilling machine, center drill and a workpiece, the student will center drill the workpiece to the specified performance criteria.	Accuracy - the center drilled holes will be drilled to standard size ± 1/32" with a surface finish of 125 microinches or better. Time - the operation will be performed to the industry standard.
MEASUREMENT I			
1	Measure with steel rule	Given a steel rule and testpieces with known dimensions, the student will measure the testpieces to the specified performance criteria.	Accuracy - measure the testpiece dimensions to 1/64". Time - make the measurements to the industry standard.
2	Measure with an outside micrometer	Given a micrometer and testpieces with known dimensions, the student will measure the testpieces to the specified performance criteria.	Accuracy - measure the testpiece dimensions to ± .001". Time - make the measurements to the industry standard.

TASK #	TASK DESCRIPTION	PERFORMANCE OBJECTIVE	PERFORMANCE CRITERIA
MEASUREMENT I (cont'd):			
3	Measure with a vernier caliper	Given a vernier caliper and testpieces with known dimensions, the student will measure the testpieces to the specified performance criteria.	Accuracy - measure the testpiece dimensions to ± .002". Time - make the measurement to the industry standard.
4	Measure with an inside micrometer	Given an inside micrometer and testpieces with known dimensions, the student will measure the testpieces to the specified performance criteria.	Accuracy - measure the testpiece dimensions to ± .001". Time - make the measurement to the industry standard.
5	Measure with small hole gages	Given a set of small hole gages, a 0-1 inch micrometer, and testpieces with known dimensions, the student will measure the testpieces to the specified performance criteria.	Accuracy - measure the testpiece dimensions to ± .001". Time - make the measurements to the industry standard.
6	Measure with telescope gages	Given a set of telescope gages and testpieces with known dimensions, the student will measure the testpieces internal diameters to the specified performance criteria.	Accuracy - measure the testpiece internal diameters to ± .002". Time - make the measurements to the industry standard.
7	Measure with a depth rule	Given a depth rule and testpieces with known dimensions, the student will measure the testpieces to the specified performance criteria.	Accuracy - measure the testpiece dimensions to ± 1/64". Time - make the measurements to the industry standard.
8	Measure with a depth micrometer	Given a depth micrometer set and testpieces with known dimensions, the student will measure the testpieces to the specified performance criteria.	Accuracy - measure the testpiece dimensions to ± .002". Time - make the measurements to the industry standard.

TASK #	TASK DESCRIPTION	PERFORMANCE OBJECTIVE	PERFORMANCE CRITERIA
MEASUREMENT I (cont'd):			
9	Measure with depth vernier	Given a depth vernier and testpieces with known dimensions, the student will measure the testpieces to the specified performance criteria.	Accuracy - measure the testpieces to ± .002". Time - make the measurements to the industry standard.
10	Measure with a protractor	Given a plain steel protractor or a steel rule with protractor head and testpieces with known angle measurements, the student will measure the testpiece angles to the specified performance criteria.	Accuracy - measure the testpiece angles to ± 1°. Time - make the measurements to the industry standard.
		Given a vernier bevel protractor and testpieces with known angle measurements, the student will measure the testpiece angles to the specified performance criteria.	Accuracy - measure the testpiece angles to ± 5'. Time - make the measurements to the industry standard.
11	Measure with a dial indicator	Given a dial indicator, a 1" gage block, and testpieces of known height, the student will measure the testpieces to the specified performance criteria.	Accuracy - measure the testpiece heights to ± .0005". Time - make the measurements to the industry standard.
12	Measure angles with a sine plate	Given a sine plate, a set of gage blocks, a dial indicator and testpieces with known angles, the student will measure the angles to the specified performance criteria.	Accuracy - measure the angles to within 2' of arc. Time - make the measurements to the industry standard.
13	Measure with dial bore gages	Given a dial bore gage with accessories and several testpieces of known internal diameters, the student will check the testpiece diameters to the specified performance criteria.	Accuracy - measure the internal diameters to .0001" accuracy. Time - make the measurements to the industry standard.

TASK #	TASK DESCRIPTION	PERFORMANCE OBJECTIVE	PERFORMANCE CRITERIA
MEASUREMENT I (cont'd):			
14	Measure with micrometer hole gages (intrimiks)	Given a set of intrimiks and several testpieces of known internal diameters, the student will measure the testpiece diameters to the specified performance criteria.	Accuracy - measure the testpiece diameters to ± .0002 accuracy. Time - make the measurements to the industry standard.
15	Measure with radius gages	Given a radius gage set and testpieces of having known radii, the student will measure the testpiece radii to the specified performance criteria.	Accuracy - measure the testpiece radii to ± 1/64". Time - make the measurements to the industry standard.
16	Measure contours on the optical comparator	Given an optical comparator, a contour template, and testpieces with known contour dimensions, the student will measure the testpiece contour to the specified performance criteria.	Accuracy - measure the testpiece contours to ± .005". Time - make the measurements to the industry standard.
	Measure angles on the optical comparator	Given an optical comparator, an angle template, and testpieces with known angles, the student will measure the angles to the specified performance criteria.	Accuracy - measure the testpiece angles to ± 15 minutes of arc. Time - make the measurements to the industry standard.
17	Measure with thread micrometer	Given a thread micrometer and testpieces with known thread pitch diameters, the student will measure the pitch diameters to the specified performance criteria.	Accuracy - measure the testpiece thread pitch diameters to ± .001". Time - make the measurements to the industry standard.
18	Measure thread pitch diameters with Go-No Go ring gages	Given sets of thread ring gages for several thread sizes and threaded testpieces of known pitch diameters, the student will select the good threads to the specified performance criteria.	Accuracy - check the threaded testpieces and select correct threads to 100% accuracy. Time - check the threads and make the selection to the industry standard.

TASK #	TASK DESCRIPTION	PERFORMANCE OBJECTIVE	PERFORMANCE CRITERIA
MEASUREMENT I (cont'd):			
19	Check concentricity with bench center and dial indicator	Given a bench center, a dial indicator, and a testpiece with known concentricity, the student will check the testpiece concentricity to the specified performance criteria.	Accuracy - check the testpiece concentricity to ± .0005". Time - make the check to the industry standard.
21	Measure with a thread plug gage	Given a three thread plug gages and several threaded testpieces, the student will select the good threads to the specified performance criteria.	Accuracy - check the threaded testpieces and select the correct threads to 100% accuracy. Time - check the threads and make the selection to the industry standard.
22	Measure hardness with Rockwell hardness tester	Given a Rockwell hardness tester, master testpiece, and several testpieces of known hardness, the student will check the testpiece hardness to the specified performance criteria.	Accuracy - check the testpiece hardness to ± 2 units of Rockwell hardness. Time - check the testpieces to the industry standard.
23	Measure with Toolmakers microscope	Given a Toolmaker's microscope and accessories and a testpiece with known dimensions, the student will check the testpiece dimensions to the specified performance criteria.	Accuracy - check the workpiece dimensions to ± .0005". Time - make the checks to the industry standard.
24	Check hole location by coordinate method	Given a precision angle plate, height gage, dial indicator, parallel, and testpiece, the student will check the hole locations to the specified criteria.	Accuracy - check the X & Y hole locations to ± .002" accuracy. Time - make the checks to the industry standard.
25	Check hole location by true position method	Given a surface plate, precision angle plate, dial indicator, height gage and a testpiece with known hole locations, the student will check true position locations to the specified criteria.	Accuracy - check true positional hole location to ± .002" accuracy. Time - make the checks to the industry standard.

TASK #	TASK DESCRIPTION	PERFORMANCE OBJECTIVE	PERFORMANCE CRITERIA
MEASUREMENT I (cont'd):			
26	Check precision square for squareness using cylindrical square	Given a precision square, cylindrical square, granite surface plate, and feeler gages, the student will check the squareness of the precision square to the specified criteria.	Accuracy - the squareness of the precision square will be identified to .001" in length of blade. Time - the squareness check will be done to the industry standard.
27	Measure squareness with precision square	Given a precision square, set of feeler gages, and several testpieces of known squareness, the student will check the testpieces for squareness to the specified criteria.	Accuracy - check the squareness of the testpieces to .001" accuracy. Time - make the squareness checks to the industry standard.
POWER HACK SAW I			
1	Power hack saw operational control familiarity (Marvel)	Given a power hack saw, the student will operate the hack saw to the specified performance criteria.	Accuracy - the power hack saw will be operated to the satisfaction of the instructor. Time - the operation will be performed to the industry standard.
2	Install hack saw blade	Given a power hack saw and hack saw blade, the student will install the blade to the specified performance criteria.	Accuracy - the blade will be installed to the satisfaction of the instructor. Time - the operation will be performed to the industry standard.
3	Cut off stock in the power hack saw	Given a power hack saw, the student will cut off stock to the specified performance criteria.	Accuracy - the stock will be cut to length within ± 1/8". Time - the operation will be performed to the industry standard.

TASK #	TASK DESCRIPTION	PERFORMANCE OBJECTIVE	PERFORMANCE CRITERIA
VERTICAL MILLING MACHINE I:			
1	Vertical milling machine operating control familiarity (Bridgeport)	Given a vertical mill, the student will operate the mill to the specified performance criteria.	Accuracy - the mill will be operated to the satisfaction of the instructor. Time - the operation will be performed to the industry standard.
2	Install and remove a coolet and end mill	Given a vertical mill, collet set and end mill, the student will install and remove the collet and end mill to the specified performance criteria.	Accuracy - the collet and end mill will be installed and removed to the satisfaction of the instructor. Time - the operation will be performed to the industry standard.
3	Align spindle perpendicular to the table	Given a vertical mill and dial indicator, the student will align the spindle and table to the specified performance criteria.	Accuracy - the table and spindle will be aligned not to exceed .0005" per inch of radius. Time - the operation will be performed to the industry standard.
4	Mount and align a vise on the mill table	Given a vertical mill, a vise, and dial indicator, the student will mount and align the vise to the specified performance criteria.	Accuracy - the vise will be aligned to .001 TIR in 5" of travel. Time - the operation will be performed to the industry standard.
5	Square a workpiece clamped to the mill table	Given a vertical mill, vise, end mill, clamp set and a workpiece, the student will square the workpiece to the specified performance criteria.	Accuracy - the workpiece dimensions must be in tolerance and squareness held to .002" TIR on a side. Time - the operation will be performed to the industry standard.
6	Square a workpiece held in a vise on vertical mill	Given a vertical mill, vise, end mill and a workpiece, the student will square the workpiece to the specified performance criteria.	Accuracy - the workpiece dimensions must be in tolerance and squareness held to .002" TIR on a side.

TASK #	TASK DESCRIPTION	PERFORMANCE OBJECTIVE	PERFORMANCE CRITERIA
VERTICAL MILLING MACHINE I (cont'd):			
			Time - the operation will be performed to the industry standard.
7	Locating, drilling and reaming holes by coordinate method	Given a vertical mill, vise, selected drills and reamers and a workpiece, the student will drill and ream holes to the specified performance criteria.	Accuracy - the holes will be drilled to $^{+ .010}_{- .001}$ inches, reamed to $^{+ .003}_{- .001}$ inches, and located to $\pm$ .010 inches with a surface finish of 63 microinches or better. Time - the operation will be performed to the industry standard.
8	Locate and bore holes - coordinate method	Given a milling machine, dial indicator, boring head and boring tool, vise, parallels and a workpiece, the student will bore holes to the specified performance criteria.	Accuracy - the bored holes will be held to $\pm$ .001", location of the holes to $\pm$ .002" with a surface finish of 63 microinches or better. Time - the operation will be performed to the industry standard.
9	Step drill holes accurately to size	Given a vertical mill, selected drills, and a workpiece, the student will step drill holes to the specified performance criteria.	Accuracy - the holes will be drilled to $\pm$ .003" in size and $\pm$ 1/32" location with surface finish of 125 microinches or better. Time - the operation will be performed to the industry standard.
10	Mill a slot or pocket	Given a vertical mill, vise, parallels, and workpiece, the student will mill a slot and pocket to the specified performance criteria.	Accuracy - the slot will be milled to the print dimensions with a surface finish of 125 microinches or better. Time - the operation will be performed to the industry standard.
11	Countersinking, counterboring, spotfacing	Given a vertical mill, countersinking, counterboring, spotfacing tools, vise, and a workpiece, the student will	Accuracy - the countersink, counterbore, and spotface will be done to the print size and location dimensions and tolerances.

TASK #	TASK DESCRIPTION	PERFORMANCE OBJECTIVE	PERFORMANCE CRITERIA
VERTICAL MILLING MACHINE I (cont'd):			
		countersink, counterbore, and spotface to the specified performance criteria.	Time - the operation will be performed to the industry standard.
12a	Mill a square on a workpiece	Given a vertical mill, spacer, end mill and a workpiece, the student will mill a square to the specified performance criteria.	Accuracy - the size dimensions of the square will be held to ± .003" with the sides parallel within .002" and the surface finish 125 microinches or better Time - the operation to be performed to the industry standard.
12b	Mill a hexagon on a workpiece	Given a vertical mill, spacer, end mill and a workpiece, the student will mill a hexagon to the specified performance criteria.	Accuracy - the hexagon size dimensions will be held to ± .003" with the sides parallel within .002" and a surface finish of 125 microinches or better. Time - the operation will be performed to the industry standard.
13	Machine a flat surface using a fly cutter	Given a vertical mill, vise, fly cutter and workpiece, the student will fly cut the workpiece to the specified performance criteria.	Accuracy - the surface shall be flat to .002" with a surface finish of 125 microinches or better. Time - the operation will be performed to the industry standard.
14a	Drill and ream equally spaced holes using direct indexing.	Given a vertical mill, index head, dial indicator, drill, reamer, and workpiece, the student will drill and ream holes to the specified performance criteria.	Accuracy - the reamed holes will be held to $^{+ .003}_{- .000}$ inches, the location dimensions to ± .002 with a surface finish of 63 microinches or better. Time - the operation will be performed to the industry standard.

TASK #	TASK DESCRIPTION	PERFORMANCE OBJECTIVE	PERFORMANCE CRITERIA
VERTICAL MILLING MACHINE I (cont'd):			
14b	Drill and ream equally spaced holes using simple indexing	Given a vertical mill, index head, dial indicator, drills, reamers and workpiece, the student will drill and ream holes to the specified performance criteria.	Accuracy - the reamed holes will be held to $^{+ .003}_{- .000}$ inches, the location dimensions to ± .002" with a surface finish of 63 microinches or better. Time - the operation will be performed to the industry standard.
15	Mill a part using a 180° tracer unit	Given a vertical mill, tracer unit, two vises, milling cutters, workpiece and pattern, the student will trace the workpiece to the specified performance criteria.	Accuracy - all surfaces will be within ± .005" of print dimensions with a surface finish of 250 microinches or better. Time - the operation will be performed to the industry standard.
16	Mill multi-level surfaces	Given a vertical mill, vise, end mill, indicator and a workpiece, the student will mill multi-level surfaces to the specified performance criteria.	Accuracy - the dimensions will be held to ± .002" with a surface finish of 125 microinches or better. Time - the operation will be performed to the industry standard.
17	Machine a fillet with ball end mill	Given a vertical mill, vise, ball end mill, indicator, and workpiece, the student will mill a fillet to the specified performance criteria.	Accuracy - the fillet surface shall not exceed the radius in any part by more than .010" with a surface finish of 125 microinches or better. Time - the operation will be performed to the industry standard.
18	Machine a taper using a tilting table	Given a vertical mill, tilting table attachment, end mill and workpiece, the student will mill a taper to the specified performance criteria.	Accuracy - the taper will be within .002" of the specified taper per inch with a surface finish of 125 microinches or better. Time - the operation will be performed to the industry standard.

TASK #	TASK DESCRIPTION	PERFORMANCE OBJECTIVE	PERFORMANCE CRITERIA
VERTICAL MILLING MACHINE I (cont'd):			
21	Tap holes using a tapping attachment	Given a vertical milling machine, tapping head, vise, and workpiece, the student will tap holes to the specified performance criteria.	Accuracy - the threaded holes must fit class 2 Go-No Go gages. Time - the operation will be performed to the industry standard.
22	Drill holes using a drill jig	Given a vertical mill, drill jig, drills, and a workpiece, the student will drill holes using the jig to the specified performance criteria.	Accuracy - the holes will be drilled to ± .003" in size and ± .003" in location. Time - the operation will be performed to the industry standard.

GENERAL MACHINIST TRACK

M = Manipulation
P = Precision
A = Articulation

STUDENTS

Task No. - Name	SKILL TASK REQ'D	M	P	A	M	P	A	M	P	A	M	P	A	M	P	A	M	P	A	M	P	A	M	P	A
DO-ALL SAW I																									
1. Contour saw operation control familiarity.	P																								
2. Butt weld a blade.	M																								
3. Mount up a set of saw guides.	M																								
4. Mount and remove a saw band.	P																								
5. Mount and remove a file band.	M																								
6. Sawing to layout lines.	M																								
DRILLING MACHINE I																									
1. Drill press operational control familiarity.	A																								
2. Sharpen a drill by hand.	P																								
3. Mount and hold work on the drill press.	P																								
4. Drill holes to layout lines.	M																								
5. Drill holes through the center of round stock.	M																								
6. Step drill holes accurately to size.	P																								
7. Drill holes using a drill jig.	M																								
8. Countersink, counterbore and spotface.	P																								
9. Ream holes to size.	P																								
11. Tap holes in drill press by hand.	P																								
GRINDING MACHINES I																									
1. Bench or floor type grinder operation control familiarity.	A																								
3. Dressing a floor type grinding wheel.	P																								
4. Blanchard grinder operational control familiarity.	M																								
5. Dress a blanchard grinding wheel.	M																								

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		M	P	A	M	P	A	M	P	A	M	P	A	M	P	A	M	P	A	M	P	A	M	P	A
GRINDING MACHINES I (cont'd)																										
6. Blanchard grind part parallel and to size.	M																									
7. Surface grinder operation control familiarity.	M																									
8. Dress surface grinding wheel.	P																									
9. Grind a part parallel and to size.	P																									
10a. Remove and mount a surface grinding wheel.	M																									
10b. Remove and mount a grinding wheel on tool & cutter grinder.	M																									
12. Cylindrical grinder operational control familiarity.	M																									
13. Dress cylindrical grinding wheel.	M																									
14. Grind a cylindrical part between centers.	M																									
15. Grind a tapered part between center points.	M																									
16. Tool and cutter grinder operation control familiarity.	M																									
17. Grinding a cutter tool to print or signature.	M																									
HORIZONTAL MILLING MACHINE I																										
1. Operation control familiarity.	M																									
2. Install arbor in the spindle.	M																									
3. Install a cutter on the arbor.	M																									
4. Slab mill a piece square held in a vise.	M																									
5. Face mill a part clamped to table.	M																									
6. Straddle mill a part clamped to table.	M																									
7. Mount dividing head and foot stock.	M																									

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		M	P	A	M	P	A	M	P	A	M	P	A	M	P	A	M	P	A	M	P	A	M	P	A	M	P	A
HORIZONTAL MILLING MACHINE I (cont'd)																											
8. Cut teeth on a spur gear.	M																										
9. Cut keyway in shaft with plain milling cutter.	M																										
13. Machine an external radius.	M																										
14. Mill an angular slot.	M																										
17. Slit work held in vise.	M																										
23. Mill multi-level surfaces.	M																										
LATHES I																											
1. Grinding a right hand turning tool.	A																										
2. Lathe operator control familiarity.	A																										
3. Install and remove chucks and face plates - cam lock.	M																										
4. Install and remove chucks and face plates - thr'd nose.	M																										
5. Install and remove chucks and face plates - taper key.	M																										
6. Rough centering in a 4-jaw chuck.	P																										
7. Facing in a chuck.	A																										
8. Center drilling in chucks and collets.	A																										
9. Alignment of lathe centers.	M																										
10. Mounting work between centers.	M																										
11. Straight turning between centers.	M																										
12. Knurling.	M																										
13. Taper cutting - offset method.	M																										
14. Straight turning work in a chuck.	A																										
15. Precision centering in a 4-jaw chuck.	M																										
16. Cutting steep tapers and chamfers.	A																										

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LATHES : (cont'd)																									
17. Drilling in a lathe.	A																								
18. Reaming in a lathe.	A																								
19. Grooving and parting operations.	P																								
20. Grind a 60° threading tool.	M																								
21. Cutting external threads.	M																								
22. Grinding a radius tool.	M																								
23. Grinding a round nose form tool.	M																								
24. Radius and fillet turning.	P																								
25. Boring in an engine lathe.	A																								
26. Cutting internal threads.	M																								
27. Center drilling work between centers.	M																								
28. Grinding a right hand facing tool.	M																								
29. Facing work to length between centers.	M																								
30. Taper turning - taper attachment.	M																								
31. Tapping threads in a lathe.	P																								
32. Mounting, facing and turning work on a mandrel.	M																								
33. Rough and finish turning using cemented carbides and ceramics.	P																								
35a. Changing jaws in a 4-jaw independent chuck.	M																								
35b. Changing the jaws in a 3-jaw universal chuck with a set of inside and outside jaws.	M																								
35c. Reversing the jaws in a 3-jaw universal chuck with cap screw mounted jaws.	M																								
36. Machining a part with a tracing attachment.	M																								

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LATHES I (cont'd)																									
37. Reaming a tapered hole.	M																								
38. Using a steady rest.	M																								
LAYOUT AND BENCH WORK I																									
1. Rough layout.	P																								
2. Precision layout.	P																								
3. Sawing with hand hack saw.	M																								
4. Straight and draw filing.	M																								
5. Sizing holes with hand reamers.	M																								
6. Cutting threads by hand with taps.	M																								
7. Hand methods of deburring parts.	A																								
8. Hand methods of removing broken studs.	M																								
9. Cutting threads by hand with dies.	M																								
15. Center drilling in center drilling machine.	M																								
MEASUREMENT I																									
1. Measure with steel rule.	A																								
2. Measure with outside micrometer.	A																								
3. Measure with vernier caliper.	A																								
4. Measure with inside mike.	A																								
5. Measure with small hole gages.	A																								
6. Measure with a telescoping gage.	P																								
7. Measure with a depth rule.	M																								
8. Measure with depth mike.	A																								
9. Measure with depth vernier.	M																								
10. Measuring with protractors.	P																								

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		M	P	A	M	P	A	M	P	A	M	P	A	M	P	A	M	P	A	M	P	A	M	P	A	M	P	A
MEASUREMENT I (cont'd)																											
11. Measuring with a dial indicator.	A																										
12. Measuring angles and taper with a sine plate.	M																										
13. Measure with dial bore gages.	A																										
14. Measure with intri-micrometers.	P																										
15. Measure with radius gages.	A																										
16. Measure with optical comparator.	M																										
17. Measuring with thread micrometers.	M																										
18. Measure thread pitch dia. (GO, No-Go).	A																										
19. Check concentricity (center and indicator).	P																										
21. Measuring with a thread plug gage.	P																										
22. Measure hardness of metal with a Rockwell Hardness tester.	M																										
23. Measuring with the toolmakers microscope.	M																										
24. Check hole location by coordinate method (surface plate setup).	M																										
25. Check hole location by true position method.	M																										
26. Check precision square for squareness with cylindrical square.	M																										
27. Check squareness with a precision square.	P																										
28. Checking surface finish with a surface comparator gage.	M																										
29. Measure hole dia. with deltronic pins.	M																										

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POWER HACK SAW I																									
1. Power hack saw operational control familiarity.	M																								
2. Install hack saw blade.	M																								
3. Cut off stock in the power hack saw.	P																								
VERTICAL MILLING MACHINE I																									
1. Vertical milling operational control familiarity.	M																								
2. Chuck end mill in collet in spindle.	M																								
3. Align spindle perpendicular to table.	P																								
4. Mount and align a vise to the table.	A																								
5. Square a piece of work clamped to the table.	P																								
6. Square work held in a vise.	A																								
7. Locate, drill and ream holes - coordinate method.	M																								
8. Locate and bore holes - coordinate method.	M																								
9. Step drilling holes accurately to size.	P																								
10. Locate and mill a slot or pocket.	P																								
11. Countersinking, counterboring and spotfacing.	A																								
12a. Mill a square on a workpiece.	M																								
12b. Mill a hexagon on a workpiece.	M																								
13. Machine flat surface using fly cutter.	P																								
14a. Drill and ream equally spaced holes on a bolt circle using direct indexing.	P																								
14b. Drill and ream equally spaced holes on a bolt circle using simple indexing.	P																								

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VERTICAL MILLING MACHINE I (cont'd)																									
15. Mill a part using tracer unit.	M																								
16. Mill multi-level surfaces accurately.	P																								
17. Mill a fillet corner with a ball mill.	M																								
18. Machine a taper or wedge using a tilting table.	M																								
21. Tap holes on the vertical mill using a tapping attachment.	M																								
23. Drill holes using a drill jig.	M																								